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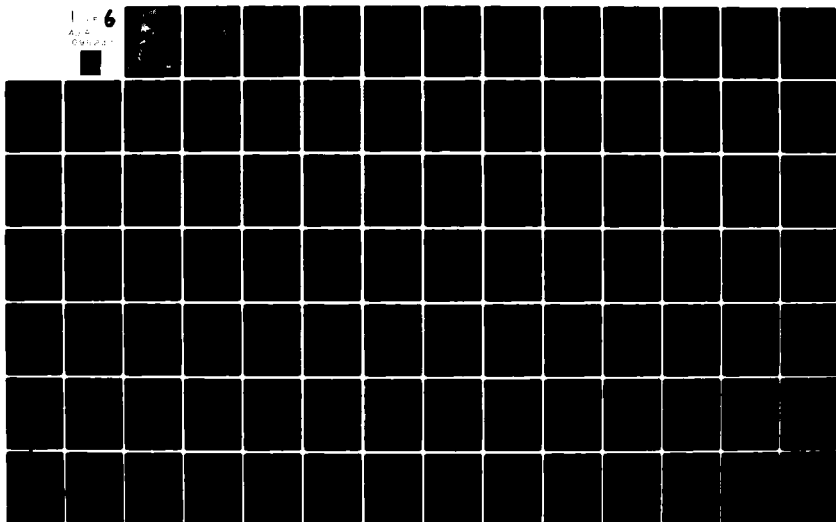
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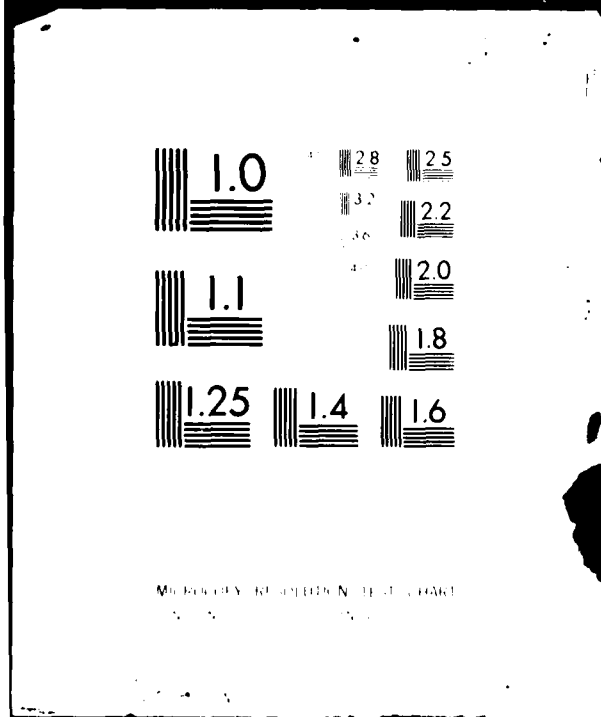
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**HUMBOLDT BAY
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AUGUST 1980



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⑥ HUMBOLDT BAY WETLANDS REVIEW
AND
BAYLANDS ANALYSIS.

Volume II.

BASE INFORMATION.

⑩ Jill/Shapiro
Marc/Boule

⑬ 4841

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Submitted to

U.S. Army Corps of Engineers
San Francisco District

⑬
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⑨ Final rpt. Sep 78 - Aug 80

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August 1980

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HUMBOLDT BAY WETLANDS REVIEW
AND BAYLANDS ANALYSIS

The information, findings, and recommendations contained in this report are those of the consultant, Shapiro and Associates, Inc., and the consultant's subcontractors. The U.S. Army Corps of Engineers, for whom the study was completed, is fully aware of the number and complexity of regulations and legislative policies of local, state, and federal agencies with jurisdictional control over Humboldt Bay. Many of these regulations and policies, and the definitions used in them, emphasize different approaches and concerns of the different agencies. The study itself is long and in many ways complex, covering many different disciplines.

Therefore, it is our hope that agencies using the study for evaluation of permit applications or proposed projects or for planning purposes may use it as a guideline, understanding that the study findings are not regulations. Any proposed project or permit application must and should be evaluated individually and on a case-by-case basis.

It should be noted that the term "dike" is sometimes used in the document in place of the word "levee." The structures in question are protective barriers erected to reclaim wetlands and remove areas from aquatic action. As such, they are technically termed "levees." Permits for such structures are processed by the Corps under Section 10 of the River and Harbor Act of 1899 and/or Section 404 of the Clean Water Act. "Dikes" are processed under Section 9 of the River and Harbor Act, together with "dams."

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PREFACE

This document is Volume II of the Humboldt Bay Wetlands Review and Baylands Analysis, prepared by Shapiro and Associates, Inc. for the San Francisco District, U.S. Army Corps of Engineers. The general study area is Humboldt Bay, California.

The complete report is in three volumes. Volume I contains the summary and findings of the study and includes the following: the study purpose, objectives, and assumptions; a description of the study area; a discussion of the importance of wetlands and a description of wetland types found in the study area; a designation of certain parts of the study area as Areas of Importance or Areas of Environmental Concern, with a discussion of the significance of the designation and a summary description of each area; a discussion of typical activities in the study area including impacts and legal/administrative processes; a summary of development pressure and an identification and discussion of areas appropriate for compensation, mitigation, and restoration; and an identification of gaps in knowledge of the area with recommendations for future studies. Volume I covers Sections I-V of the complete report. Volume I also contains a brief summary of the detailed data base presented in Volume II.

Volume II is the data base which led to and supports the findings. It is a review and discussion of known existing information on the physical, biological, land use, and sociocultural aspects of the study area. Volume II contains Sections VI, VII, and VIII of the complete report. Section VI is the environmental profile of the study area, covering physical characteristics (geography, geology and soils, geologic hazards, tidal characteristics, hydrology, physical oceanography, bottom sediments, and water quality), and biological characteristics (habitat types, fauna, ecological processes). Section VII covers land and tideland use, ownerships, and governmental agencies with interest and/or jurisdiction. Section VIII covers cultural characteristics (historical/archaeological resources, community structure, recreation, educational/scientific uses, refuges/reserves), aesthetics, and economics.

Volume III describes the detailed classification and mapping of habitat types (land cover) conducted as part of the study. The entire study area was classified and mapped from aerial color infrared photographs at a scale of 1:6000. Volume III discusses the following: the need for habitat classification and mapping; the definition and relevance of the Corps of Engineers jurisdictional boundary under Section 404 of the Federal Water Pollution Control Act Amendments of 1972 and the Clean Water Act of 1977; a review and discussion of various land cover classification systems and a description of the system used in this study; and a discussion of mapping results, accompanied by a set of maps at 1:6000 identifying land cover and tentatively delineating the wetland boundary and/or drift line. In addition, the Appendices, including the Bibliography, are found at the end of Volume III.

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Section VI

ENVIRONMENTAL PROFILES

A. GEOGRAPHY

Humboldt Bay is a coastal estuary located about 260 miles north of San Francisco in Humboldt County, California (Figure VI-1). Water in the Bay covers about 25 square miles at high tide, but only 8 square miles at low tide, the remainder being exposed as shallow tidal flats. The Bay is about 14 miles long and varies from 0.5 to 4 miles in width. Because of its general morphology, Humboldt Bay is usually divided into three distinct areas: North or Arcata Bay, Middle or Entrance Bay, and South Bay. The southwest ends of Woodley and Indian Islands may be considered the south end of North Bay. South Bay extends south of the South Spit Jetty and King Salmon. Plate 3 delineates most of the major geographic features.

Lowlands to the north and east consist of creek and river floodplains, and former tidal marshes that were drained and converted to agricultural uses. These lowlands are bordered by low foothills of the Coastal Range. Farther to the east the terrain becomes more mountainous, with elevations of 3,000-5,000 feet and narrow steep canyons. Topography of the study area is shown on Plate 3.

Separating the Bay from the ocean are two long sand spits with a narrow inlet between them. North Spit is about 10 miles long and 0.5 to 0.9 miles wide. Much of this spit consists of large dunes, up to 50 feet high and heavily forested in places. South Spit is about 4 miles long and varies from 0.1 to 0.7 miles in width; it consists of sparsely vegetated dunes much smaller than those on North Spit.

The Elk River and several small creeks enter Humboldt Bay, draining an area of approximately 223 square miles. Immediately to the north is the Mad River, that occasionally overflows into the Bay under flood conditions. To the south is the Eel River floodplain, separated from Humboldt Bay by Table Bluff.

Eureka is the principal city adjacent to Humboldt Bay. It serves as the County seat and commercial center of the region. Arcata is the only other incorporated city adjacent to the Bay, and is the location of Humboldt State University. Small communities around the Bay include Fairhaven, Samoa, Manila, Fields Landing, and King Salmon.

North Bay covers about 13 square miles, being 5.8 miles at its longest and 4.3 miles at its widest points. It is bounded by North Spit to the west, Arcata Bottoms to the north, Bayside Bottoms and Fickle Hill to the east and Eureka to the south. Indian (formerly Gunther), Woodley, and Daby Islands are all located in the southern portion of the Bay. McDaniel Slough, Jacoby Creek, and Freshwater Creek all discharge fresh water into the Bay. Mad River Slough, located in the northwest portion of North Bay, does not normally discharge fresh water. During flood conditions on the Mad River, however, flood waters may overflow into the slough, and thus into the Bay.

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TOPOGRAPHY

PLATE NO 3 NORTH

LEGEND

Elevations in Feet



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS



TOPOGRAPHY

PLATE NO 3 SOUTH

LEGEND

Elevations in Feet

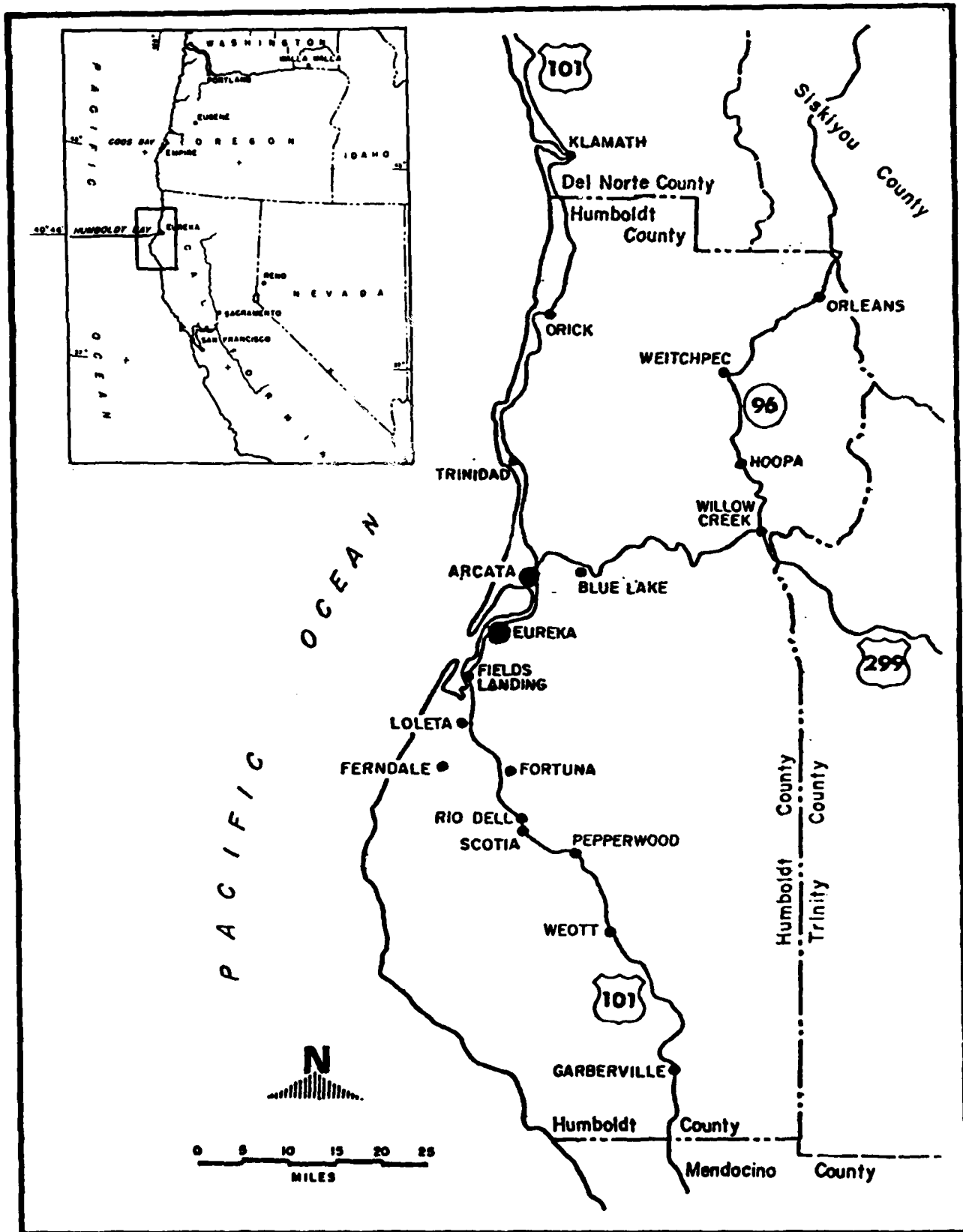


HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

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Figure VI-1

LOCATION MAP



North Bay is extremely shallow, with over one-half the area (approximately 7 square miles) exposed at low tide. These tidal flats are dissected by several deep channels and numerous shallow channels. Samoa Channel and Eureka Channel are the principal commercial waterways of North Bay, and are maintained by the Corps to a depth of 35 feet, and 26 to 35 feet respectively.

Entrance Bay is approximately 5 miles long and a maximum one mile wide. It is bounded by North Spit to the west, and Eureka and the Elk River floodplain to the east. Unlike North and South Bay, it is not characterized by broad expanses of tidal flats. Instead, it consists of a single deep channel, with generally steep sides. Elk River, the largest freshwater source in Humboldt Bay, empties into Entrance Bay.

South Bay covers approximately 7 square miles, with a maximum length of 4 miles and maximum width of about 2.5 miles. It is bounded by South Spit to the west, Humboldt Hill and Beatrice Flats to the east and Table Bluff to the south. Salmon Creek is the only freshwater source which discharges into South Humboldt Bay.

As mentioned previously, South Bay is similar to North Bay with respect to the broad expanses of tidal flats. These flats are also incised by tidal channels. Only one, the Fields Landing Channel, is utilized commercially and maintained by the Corps.

In order to analyze trends in land use within the study area, it was necessary to accurately define the study area, and several subareas. These are all indicated on Plate 1. In general, the study area boundary was the +10 elevation contour and/or the break in slope between lowlands and adjacent foothills. In some areas, a more distinct physical feature, such as Highway 101 or Old Arcata Road, was used as a boundary. Features which were considered to have important physical, biological, cultural, or economic impacts on the study area were also included even if they were located well above the 10 foot contour. Examples include North Spit, the City of Eureka, and Table Bluff.

B. CLIMATOLOGY

The Humboldt Bay region is an area of moderate temperatures and considerable precipitation. It is typified by mild, moist winters and cool, dry, foggy summers. Mean monthly temperatures along the coast generally vary only 10° from summer to winter. Rainfall occurs every month of the year in most years, though only very light amounts fall in the summer months. The climate exhibits distinct seasonal fluctuations, as is apparent in Figure VI-2.

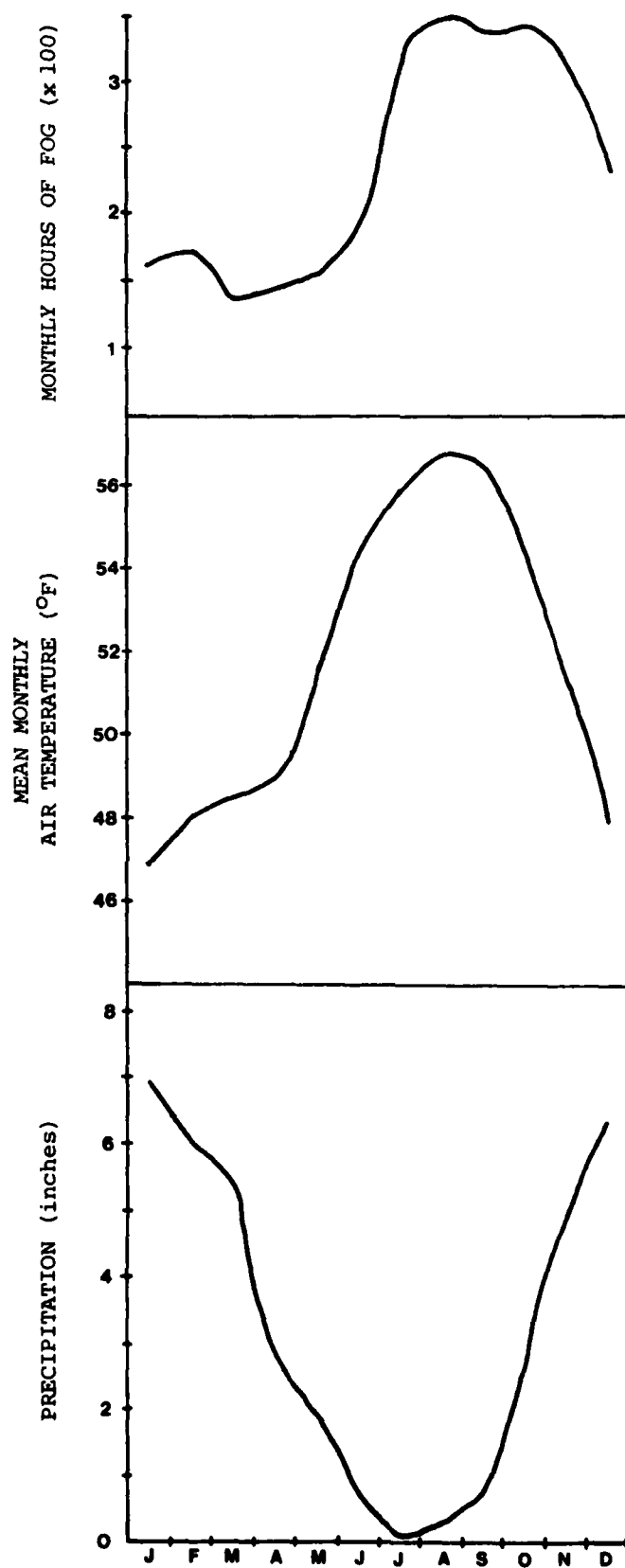
The Pacific Ocean has a twofold effect upon the climate of Humboldt Bay. Near the coast, the Pacific remains cool throughout the year, with water temperatures remaining between 51°F and 55°F. This tends to stabilize the temperature of the air blowing over the water, resulting in moderate temperatures year around along the coast. The air traveling over the Pacific also becomes saturated with moisture, resulting in high annual precipitation levels for the region.

As noted, precipitation in the Humboldt Bay area is seasonal, with pronounced "wet" and "dry" seasons. It is also sporadic, with most days in the winter experiencing low rainfall while occasional storms bring extremely high rainfall for a short period. Figure VI-3 shows daily rainfall for October 1974 to March 1975. The storm related "pulses" in precipitation are apparent.

The winds in the Humboldt Bay area are summarized in the wind rose, Figure VI-4. This figure characterizes the percent frequency of occurrence of winds by direction and speed. As can be seen, the prevailing winds in the area are generally from the north and northwest in the summer and the southeast to southwest in winter (University of Washington, 1955). They are generally light over most of the area most of the year. Strong winds usually are a result of migrant winter storms passing over the study area, or occasional thunderstorms occurring in the summer months.

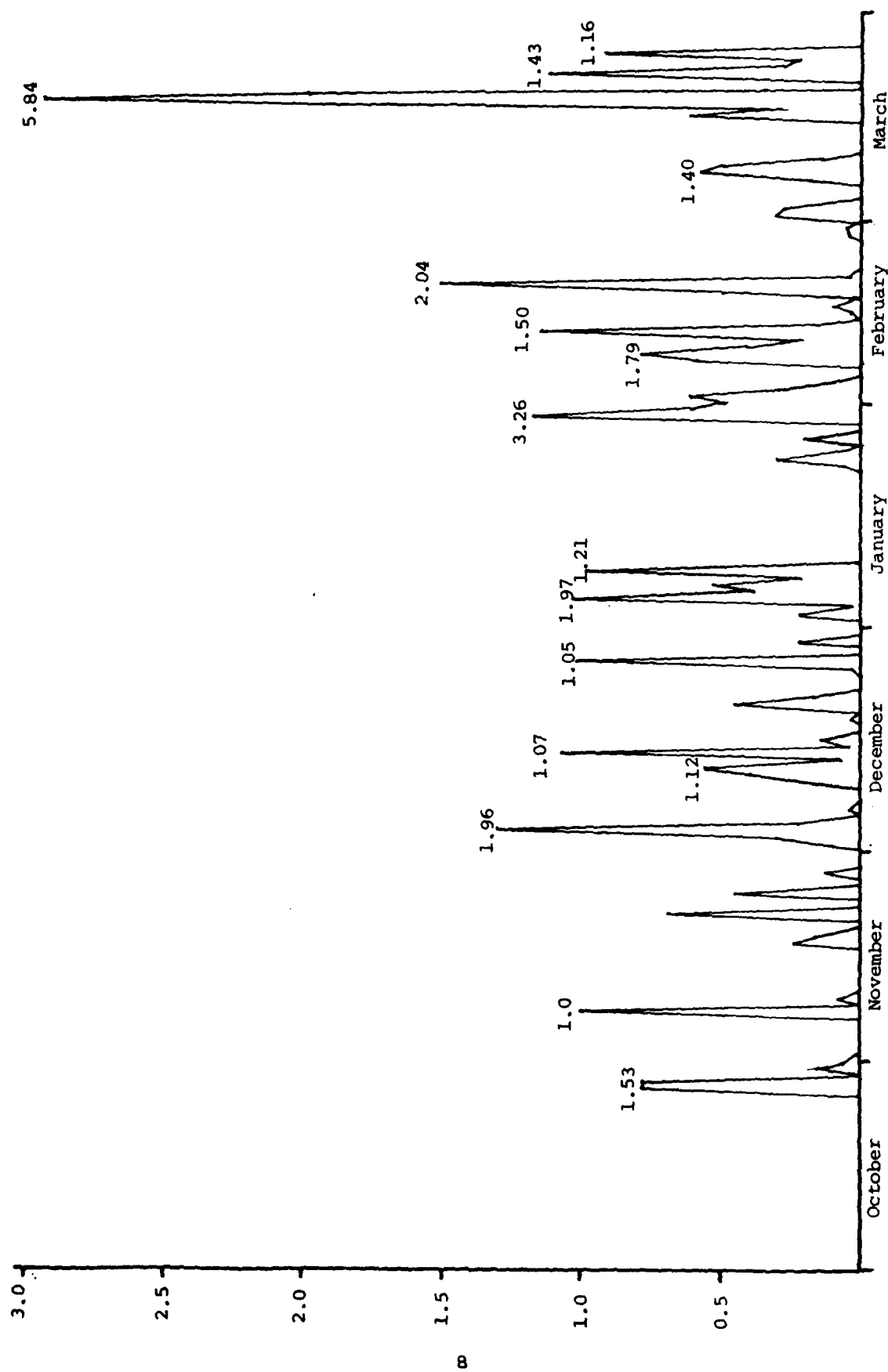
The prevailing winds in the area are largely due to the seasonal offshore weather system occurring over the northeastern section of the Pacific Ocean. In the winter months, a low pressure system exists just south of the Gulf of Alaska. This system produces counter-clockwise circulation of air around its center, which brings storms and winds into the Humboldt Bay area from the south and southwest. In the summer, a high pressure system builds up off the coast of northern California. The clockwise circulation of air from this system's center brings northerly and northwesterly winds to the study area.

The northwest winds, though persistent, tend to increase in velocity in the early afternoon and die in the late evening. These winds are caused by the interaction of two pressure systems: first, the North Pacific High which dominates the weather of the Pacific Northwest during the spring and summer months and second, a thermal low in the central valley of California which is caused by local heating of the land during the day with a concomitant rise of the valley air. The diurnal nature of the winds results in a pattern



SEASONAL CYCLES OF AIR TEMPERTATURE,
FOG, AND PRECIPITATION

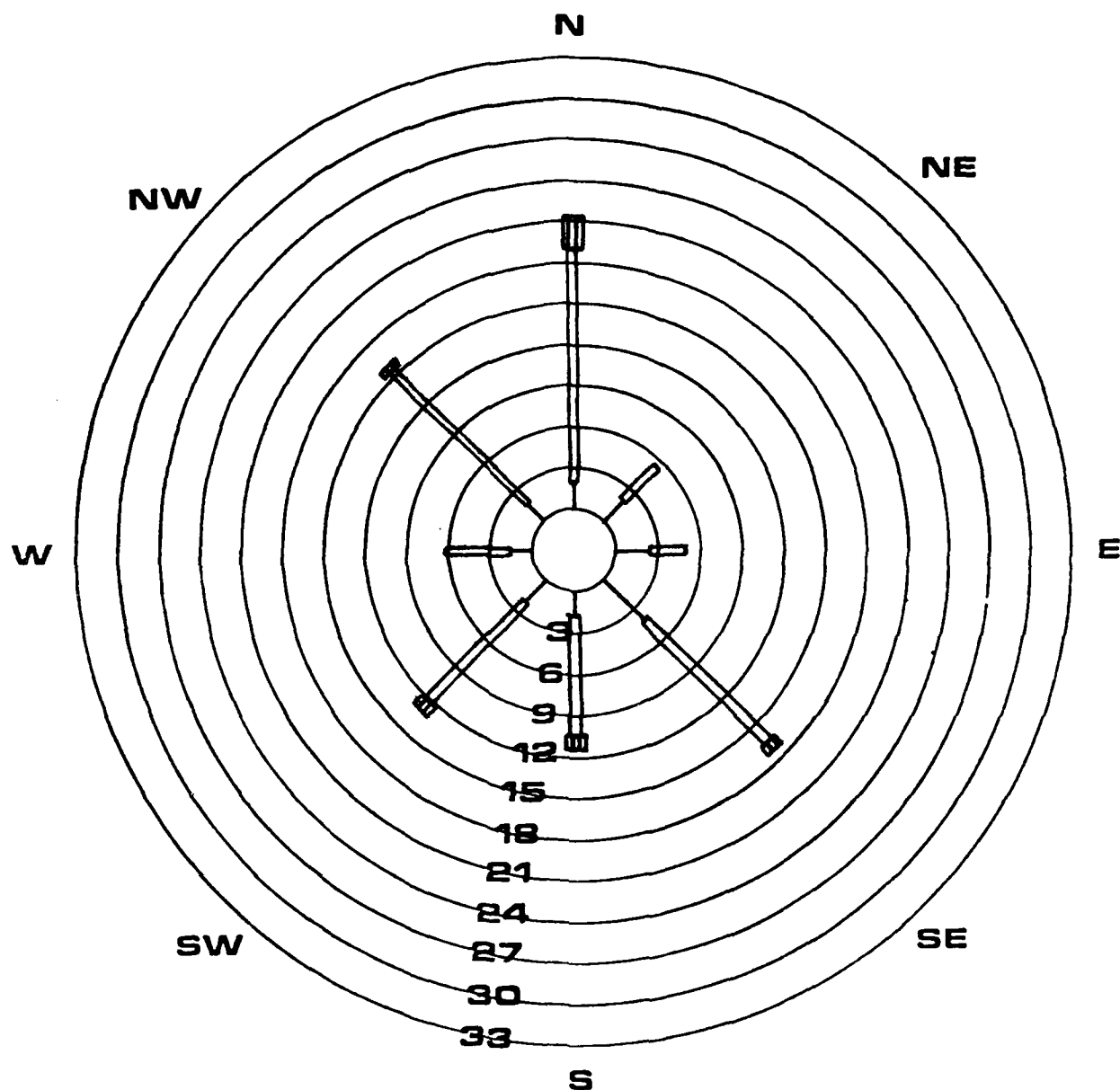
Source: U.S. Department of Commerce, 1963,
and Pacific Coast Pilot.



DAILY PRECIPITATION IN EUREKA, CALIFORNIA, OCTOBER 1974 TO MARCH 1975

(Total precipitation in inches for each storm is noted)

Source: U.S. Department of Commerce, 1975, 1976

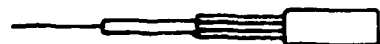


SITE LOCATION
Eureka

INCLUSIVE DATES
July 1939 - Dec 1942

TOTAL OBSERVATIONS
9002

MILES PER HOUR



1-3 4-15 16-31 32-47

Figure VI-4

Source: Corps, 1956

HOURLY AVERAGE SURFACE WINDS (MPH)
PERCENTAGE FREQUENCY OF OCCURRENCE

of heating of the central valley. They persist through the night, although at a lower intensity, because the North Pacific High is a semi-permanent feature in the spring and summer months.

One of the dominant characteristics of the Humboldt Bay region's weather is the fog, which occurs over the coastal zone, especially in the summer and early autumn. The presence of fog in the area is a product of the following series of events: land temperatures rise in the warm summer months, the air over the land is heated and tends to rise, it is then replaced at the surface by cool, moisture-laden air that moves in from the Pacific Ocean. Condensation of the moisture in this air mass results in a layer of low stratus clouds, or fog, over the coastal area. The fog only persists a short distance inland, however, as the incoming air is continually warmed until its relative humidity is reduced below the point where fog occurs. Fog affects the community in the Humboldt Bay in two ways. Primarily, the frequent occurrence of fog in the region [an annual average of 965 hours (Corps, 1927)] limits the departures and arrivals of both the fishing boat fleet and aircraft based in Humboldt Bay. Secondly, the fog tends to permeate the large redwood tree stands in the region and a significant amount of moisture is precipitated to the ground from condensation of fog on the branches of the trees. Fog also affects the area by limiting incoming solar radiation, thereby minimizing both air and water temperature maxima.

The climatological characteristics of the Humboldt Bay area determine, in part, which organisms can survive and best compete in the estuarine habitat. Climate is also an important factor to man in identifying locations to live and work. Finally, it affects the intensity and duration of air quality impacts in an area. Thus, climate has a significant influence on man and all other organisms which inhabit the area.

Air Quality

The Humboldt Bay study area is in the North Coast Air Basin. Although air quality is generally good in the study area, the state ambient air quality standards for particulate matter (PM), lead, and hydrogen sulfide, as well as national primary and secondary standards for PM, are presently violated in the Basin. Concentrations of pollutants such as sulfur dioxide, nitrogen dioxide, sulfates, and carbon monoxide are presently below standards, and the standards are not expected to be violated through 1995. No violations of oxidant standards have been recorded, but oxidants are viewed as a possible problem (ARB, 1978(1)).

Humboldt County has been declared a non-attainment area for PM (see also Section VII.C, Government Profile, EPA). Measuring stations in Arcata (fire station), Eureka (6th and I Street), and

Samoa (store) showed PM levels near or above the state standard and the national secondary standard in 1974 (ARB, 1978(1)). Monitoring through 1977 in Eureka and Arcata showed levels close to the state standard (NCAPCC, 1977). Particulate levels in 1978 were lower than in 1977 (Selfridge, 1979, personal communication). Particulate emissions are projected to be high through 1995 in Humboldt County and it appears that the state and national secondary standards will continue to be violated (ARB, 1978(1)). Control strategies to reduce particulate levels in the Basin include cyclone collection systems, teepee burners, and elimination of open burning dumps.

Lead levels were above the state standard in Arcata in 1972. It is assumed that the lead is emitted from motor vehicles in combustion of leaded gasoline. The control strategy for lead is a limitation on lead content of gasoline sold in California (ARB, 1978(1)).

Hydrogen sulfide has been an ongoing problem in the study area because of the emissions by the two kraft pulp mills located in Fairhaven and Samoa. Although standards were not violated, there were numerous citizen complaints about the odor problems from hydrogen sulfide, methyl mercaptans, and various methyl sulfides. Emissions from the pulp mills decreased from 1973 through 1976 (NCAPCC, 1977). The pulp mill odor control program was completed in 1976, and the number of citizen complaints has been greatly reduced.

C. GEOLOGY

Geologic Summary

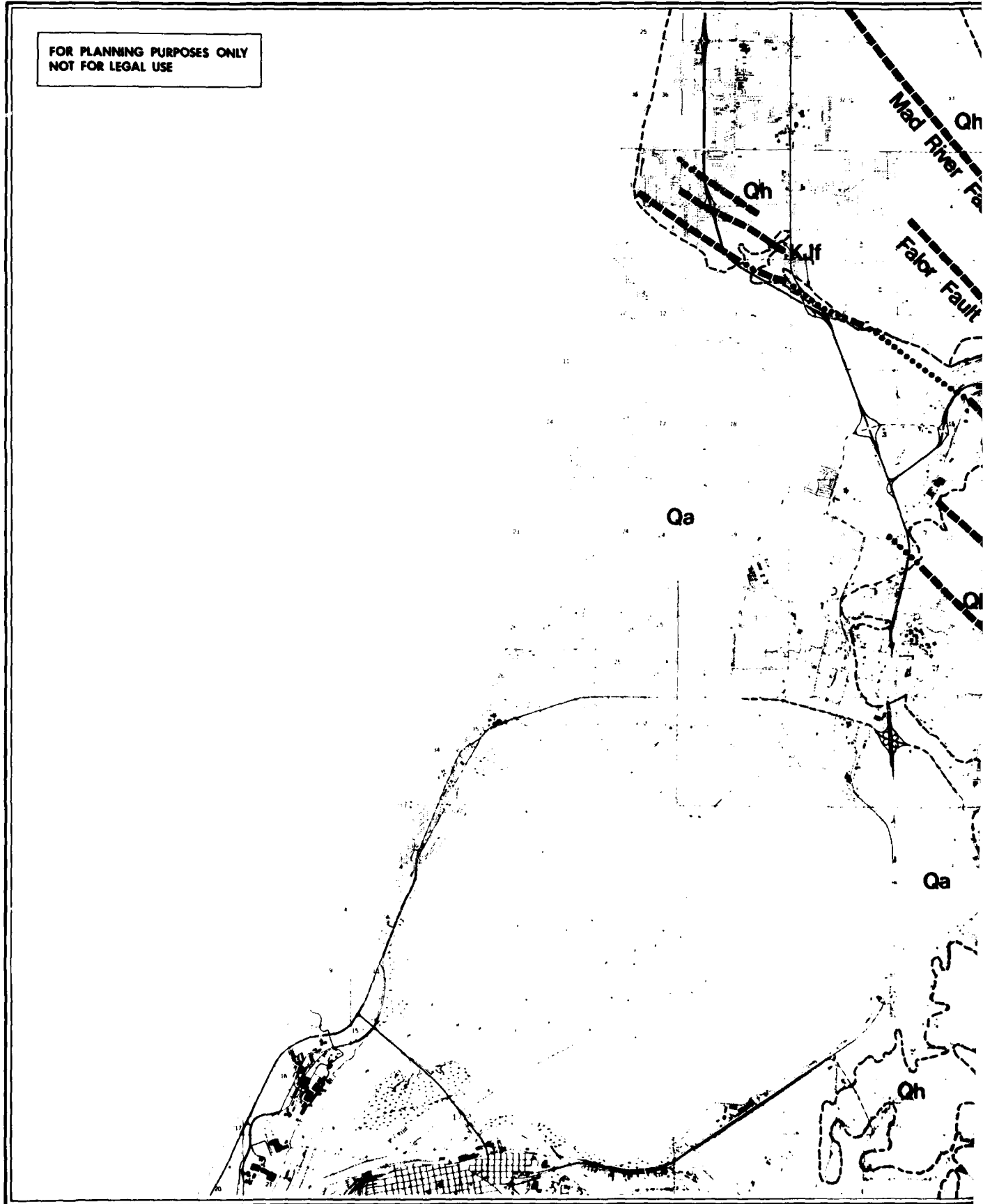
The wide range of ages and compositional diversity of the rock types exposed in the Humboldt Bay area are indications of the dynamic geologic processes that have been occurring in northwestern California. Four basic time-rock units (Table VI-1) exposed in the Humboldt Bay area include, from oldest to youngest: the Late Jurassic to Late Cretaceous Franciscan core complex, including the Yager Formation; the Late Cenozoic Wildcat Group; the Pleistocene Hookton Formation; and the Recent deposits, including tidal flats and dune deposits of Humboldt Bay, river alluvium, and landslide debris (Plate 4).

The Franciscan basement complex consists of an accumulation of over 50,000 feet of sedimentary and volcanic rocks deposited on a basaltic ocean floor that have been deformed and metamorphosed to varying degrees. In the Eel River area, up to 12,000 feet of Late Cenozoic Wildcat sedimentary strata were deposited on this Franciscan basement. Deformation of the Eel River basin through Pleistocene times has folded and faulted the Wildcat sediments, resulting in a series of northwest trending ridges, such as Table Bluff and Humboldt Hill, and the intervening valleys. Pleistocene eustatic sea-level changes superimposed on this uplifting, irregular land mass have resulted in the elevated marine and fluvial terraces and estuarine deposits of the Carlotta and Hookton Formations. During the last transgression of the sea, about 15,000 years ago, sea level was about 400 feet lower than today and the shoreline was farther west. The sea began to steadily rise, and the shoreline migrated eastward and reached its present position about 5,000 years ago. Shallow arms of the sea invaded the mouths and lowlands of the river valleys from the Mad to the Eel Rivers. Spits were formed from McKinleyville Terrace, Table Bluff, and Centerville Beach by longshore transport of river sediment and headland erosion. These spits separated the ocean from the present Humboldt Bay and the Eel River floodplain to the south. The Mad River formerly flowed directly into Arcata Bay, with distributary channels probably occupying the present courses of Liscom and McDaniel Sloughs. However, there are no data presently available that indicate when the river diverted its course northward and discharged directly into the ocean.

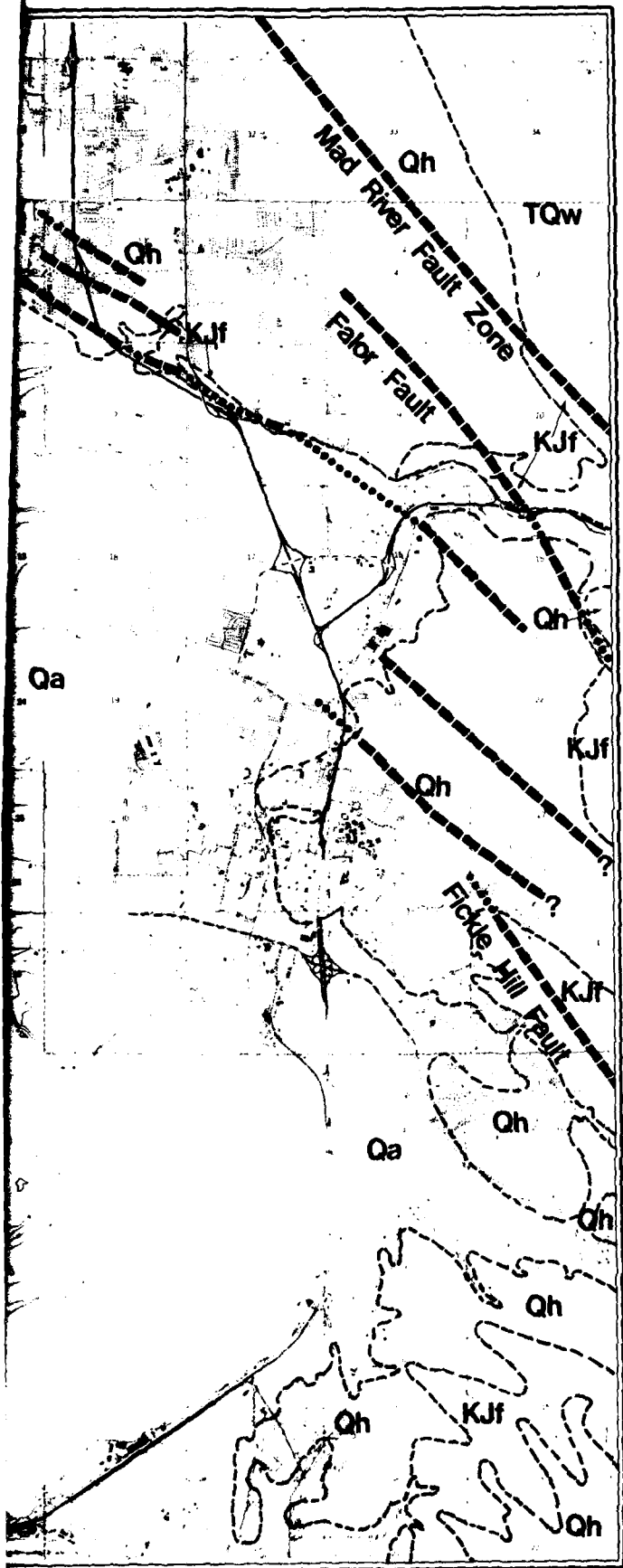
Geologic Rock Units

The following are descriptions of the rock units that are exposed in the Humboldt Bay area. These rock units are herein described in general terms since recent reevaluation by the scientific community has questioned the ages and depositional histories of these deposits. Current studies are being conducted by Woodward-Clyde Consultants for Pacific Gas and Electric Company concerning the seismic safety of the Humboldt Bay Nuclear Power Plant. These studies may have significant implications concerning the ages of the Wildcat deposits and the ages of faulting, and will be discussed in Geologic Hazards.

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NOT FOR LEGAL USE



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GEOLOGY

PLATE NO 4 NORTH

LEGEND

- Qa Recent Deposits
- Qh Hookton Formation
- TQw Wildcat Group
- KJf Franciscan Formation

Faults

- ▬▬▬ Inferred Location
- Concealed Extension

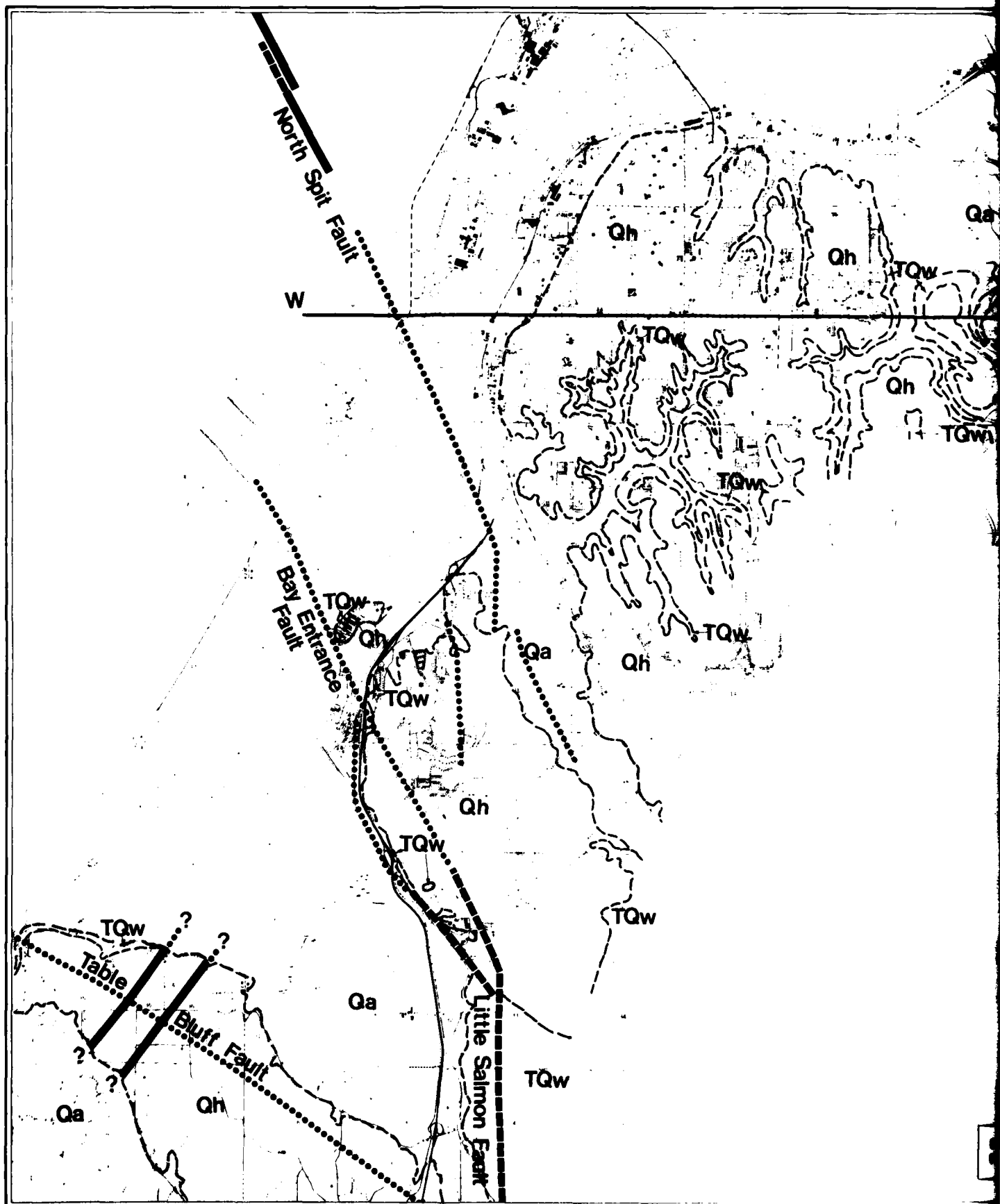
Contacts

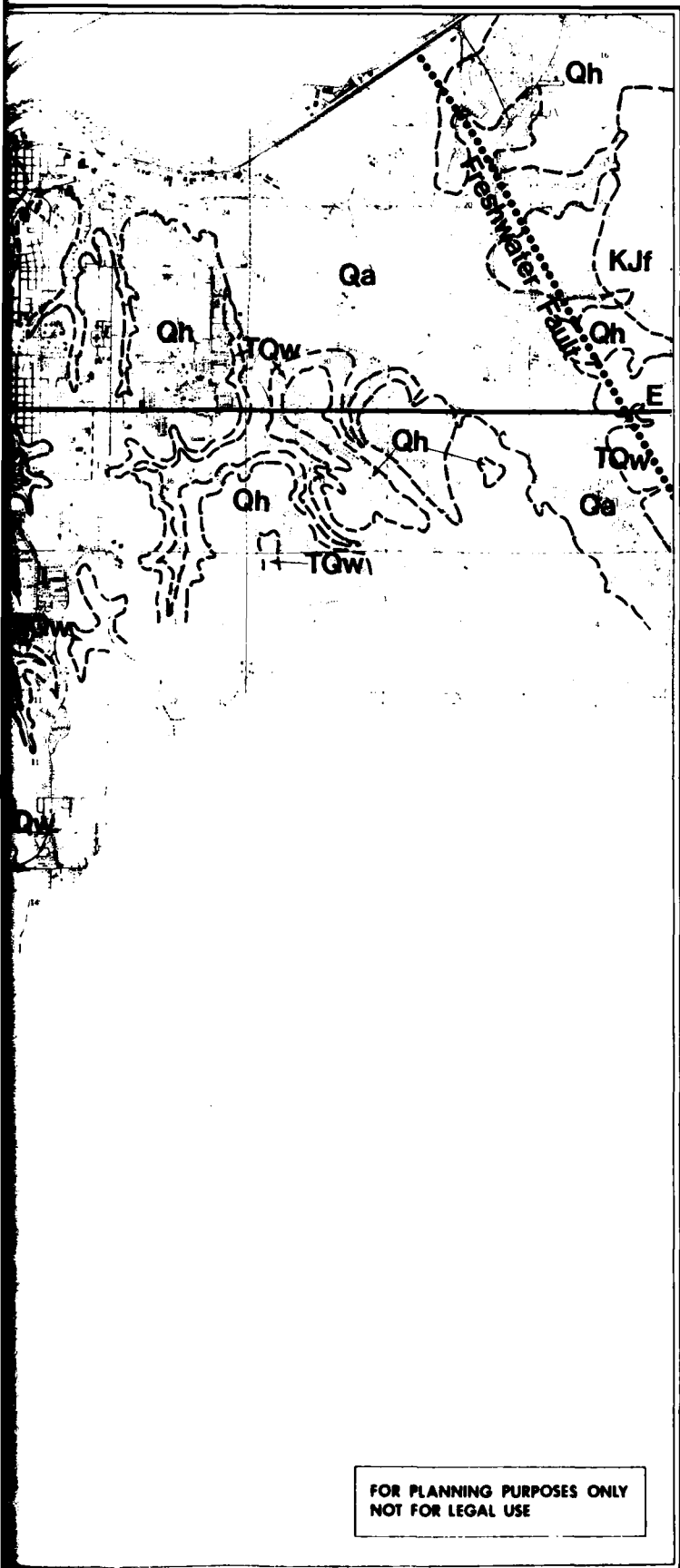
- - - - - Approx. Location



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Carver 1979
ESA 1975
Moring 1976
Ogle 1983








GEOLOGY

PLATE NO 4 SOUTH

LEGEND

- Qa Recent Deposits
- Qh Hookton Formation
- TQw Wildcat Group
- KJf Franciscan Formation

Faults

-  Approx. Location
-  Inferred Location
-  Concealed Extension

Contacts

-  Approx. Location
-  Cross Section Line



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: Earth Sciences Associates 1975
Moring 1978
Ogle 1983

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2

Table VI-1

GEOLOGIC TIME SCALE

Era		Subdivisions	Approximate Age (millions years)	Rock Units
Cenozoic	Quar- ter- nary	Holocene	.01	Recent
		Pleistocene		Hookton
	Tertiary	Pliocene	2	?
		Miocene	12	Wildcat Group
		Oligocene	25	?
		Eocene	40	
		Paleocene	60	
			70	Yager
				Franciscan
Mesozoic		Cretaceous	135	
		Jurassic	180	
		Triassic	225	
Paleozoic		Permian	350	
		Carboniferous	400	
		Devonian	440	
		Silurian	500	
		Ordovician	600	
		Cambrian		

Note: Oldest rock dated 3.5 billion years
Age of earth 4.5 billion years

The Franciscan core complex consists of a heterogenous mixture of graywacke sandstone, shale, altered basalt, chert, and a lesser amount of limestone. This assemblage of rocks was deposited in deep marine troughs, probably on a basaltic substratum. The sandstones and shales generally show low-grade metamorphic characteristics, although higher-grade blueschist tectonic blocks occur, usually in a pervasively sheared matrix of shale and serpentine. Serpentinized ultramafic rocks and blueschist are considered to be emplaced along shear zones, older large-scale faults, which may be up to a mile wide. Such shear zones are often recognized by a hummocky topography, a prevalence of landslides, and grassy, open areas that contrast to the adjacent forest or brush. Diagnostic fossils indicate that the Franciscan rocks range in age from Late Jurassic to at least Late Cretaceous. Franciscan rocks are exposed northeast of the Freshwater fault and comprise the Fickle Hill-Kneeland Ridge.

The Yager Formation (Ogle, 1953) consists of interbedded shale, graywacke, and conglomerate, with thin-bedded shale being the predominant rock type. Yager sediments were probably deposited under similar conditions as the Franciscan sediments, but are finer grained, generally lacking chert and basalt, and exhibit less intense deformation. The age of the Yager Formation and its relationships to the Franciscan rocks are poorly known, but it is considered to be at least Upper Cretaceous and may be as young as early Tertiary. Exposures are controlled in part by the downwarping and faulting of the Eel River syncline. Outcrops occur to the south of the Eel River Valley, along the False Cape shear zone, and to the northeast, where they are in fault contact with the Franciscan west of the Freshwater fault (Figure VI-5).

The Yager Formation marks a change in depositional environments from deep marine sedimentation to restricted basin deposition of clastic rocks as represented by the Wildcat Group.

The Wildcat Group consists of weakly consolidated mudstone, siltstone, sandstone, and conglomerate, with minor amounts of interbedded limestone, tuff, and lignite. Mudstone is the predominant rock type. Ogle (1953) has differentiated and named five formations based on age and lithology. The Pullen, Eel River, and Rio Dell Formations, the oldest units, range in age from Late Miocene to Upper Pliocene. These rocks are characterized by fine-grained indurated mudstones and siltstones that were deposited on the continental slope. The Scotia Bluffs Formation consists of coarse clastic shallow-marine deposits that grade into the non-marine and estuarine conglomerate, sandstone, and claystone of the Carlotta Formation. The Carlotta Formation was deposited on an irregular coastline with high relief, as shown by the rapid lateral facies changes from non-marine to marginal marine deposits. Over 12,000 feet of Wildcat strata are represented in the Eel River area, which thin towards the north, east, and southeast. They likely extend westward to at least 12 miles off-

FIGURE VI-5

REGIONAL GEOLOGIC AND FAULT MAP

Qa Alluvial Deposits
Qh Hookton Formation
TQw Wildcat Group
Ky Yager Formation
KJf Franciscan Formation

CONTACT

(Dashed where approximate,
gradational or inferred.)

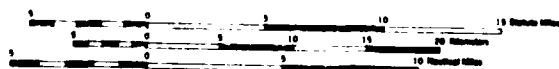
FAULT

(Dashed where approximate;
dotted where concealed.)

MENDOCINO FAULT ZONE

SAN ANDREAS FAULT

SOURCE STRAND GEOLOGIC MAP OF CALIFORNIA REDDING SHEET 1982



CONTOUR INTERVAL 200 FEET
TRANSVERSE MERCATOR PROJECTION

shore (Irwin, 1960). Exposures are largely controlled by the False Cape shear zone to the south and the Mad River fault zone to the northeast, where the Falor Formation* (Manning and Ogle, 1950) is exposed in a down-dropped block separated from the Eel River section by Fickle Hill.

Quaternary continental and marine deposits are widespread over much of the Humboldt Bay area. These Hookton sediments (Ogle, 1953) consist of perched fluvial deposits resting on intermountain valleys and along the coast near the Eel and Mad Rivers, and a thin veneer of marine sands and gravels capping wave-cut terraces. The Hookton, which is characteristically yellow-orange in color, has an extremely variable lithology, consisting of gravels, sands, silts, and clays. It is considered to be mostly non-marine in the southern Humboldt Bay area, although in a few areas it is a shallow or marginal marine deposit. Ogle states that the marine terraces north of the Mad River may be Hookton equivalents. Hookton sediments on Fickle Hill and Ridgewood Heights are also found as high as 1,200 feet above sea level (Earth Sciences Associates, Inc., 1975). For mapping in this report (Plate 4), the Hookton is considered to be composed of Middle to Late Pleistocene (Post-Carlotta) deposits consisting of discontinuous series of elevated marine terrace, intervening fluvial, floodplain, marginal-marine, and tidal flat deposits. These sediments unconformably overlies the older Wildcat sediments and have been gently folded along older structural trends or express the surface they were deposited on (Figure VI-6).

Recent deposits in the Humboldt Bay area consist of river channel and floodplain deposits, beach and dune sands, tidal flat deposits, and landslide debris. Alluvium consisting of gravel, sand, and silt has been deposited by the Mad and Eel Rivers, forming bars and delta deposits up to 20 feet thick. These sands and gravels are of economic value (see Mineral Resources). The flat-lying areas adjacent to the rivers, such as the "Arcata Bottoms," are composed of older river alluvium covered by fine-grained sediments deposited primarily during the flood stages of the rivers.

Fine-grained sands and silts are carried out to sea by the rivers, and sediments derived from coastal erosion are deposited on the beaches by longshore transport and wave action. The fine sands are blown by onshore winds and develop the large coastal dunes along the spits. Tidal action in the bay has combined sands, silts, and clays from offshore areas and sloughs, and has deposited these sediments in the intertidal areas and tidal channels (see Bottom Sediments). Extensive areas around Eureka and Arcata are reclaimed baylands and marshes from the result of diking and filling. Land-

*Falor Formation consists of marine and non-marine sedimentary rocks which are probably correlative to the Scotia Bluffs, Carlotta, and Hookton Formations.

Qa RECENT ALLUVIUM
 Oh HOOKTON FORMATION
 TQW WILDCAT GROUP
 Ky YAGER FORMATION
 KJf FRANCISCAN FORMATION

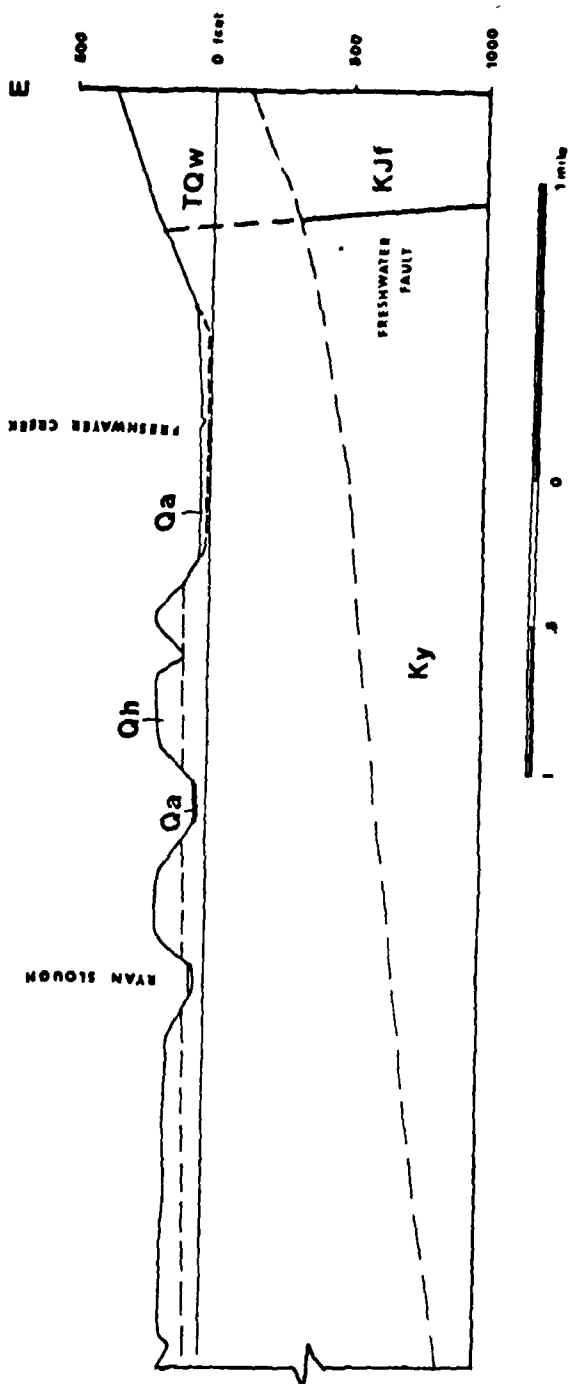
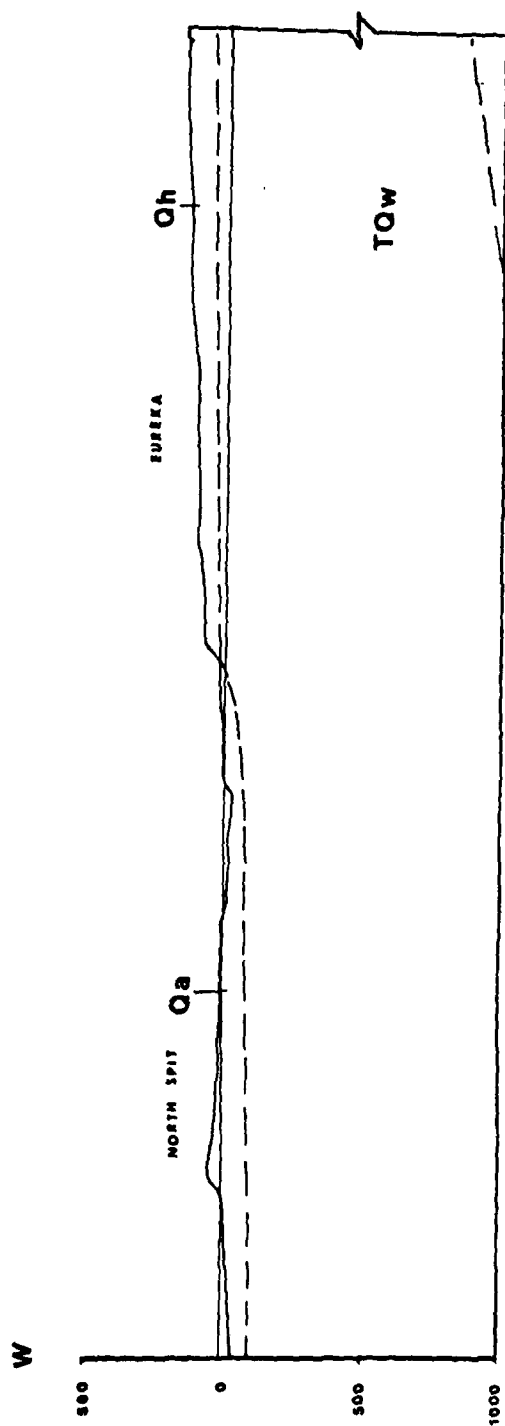


Figure VI-6
 PRELIMINARY GEOLOGIC CROSS SECTION

slides in the mountainous areas and along the steep gulches contribute sediments to the hydrologic system and are responsible for loss and damage to property (see Geologic Hazards).

Geologic Structures

Faults. Major structural patterns of the region are chiefly controlled at Cape Mendocino where the San Andreas fault bends abruptly and follows the seismically active Mendocino fracture zone (Figure VI-5). Regional north-south compression has resulted in a radial pattern of right-lateral strike-slip faults trending in a west-northwesterly direction towards the Gorda Basin. The Mad River fault zone and the Russ fault-False Cape shear zone, bound the Tertiary sediments of the Eel River syncline. These faults, and the deep seismic zone, are active and will be discussed further in Geologic Hazards.

Folds. Folding in the Wildcat sediments is generally broad and open, but dips are steep to overturned near faults. Minor fold axes within the Eel River syncline trend northwesterly, parallel to the regional structure. These include the Tompkins Hill-Table Bluff anticline, South Bay syncline, Humboldt Hill-North Spit anticline, and the Arcata Bay syncline. Quaternary marine terrace deposits are gently folded along these older trends.

D. GEOLOGIC HAZARDS

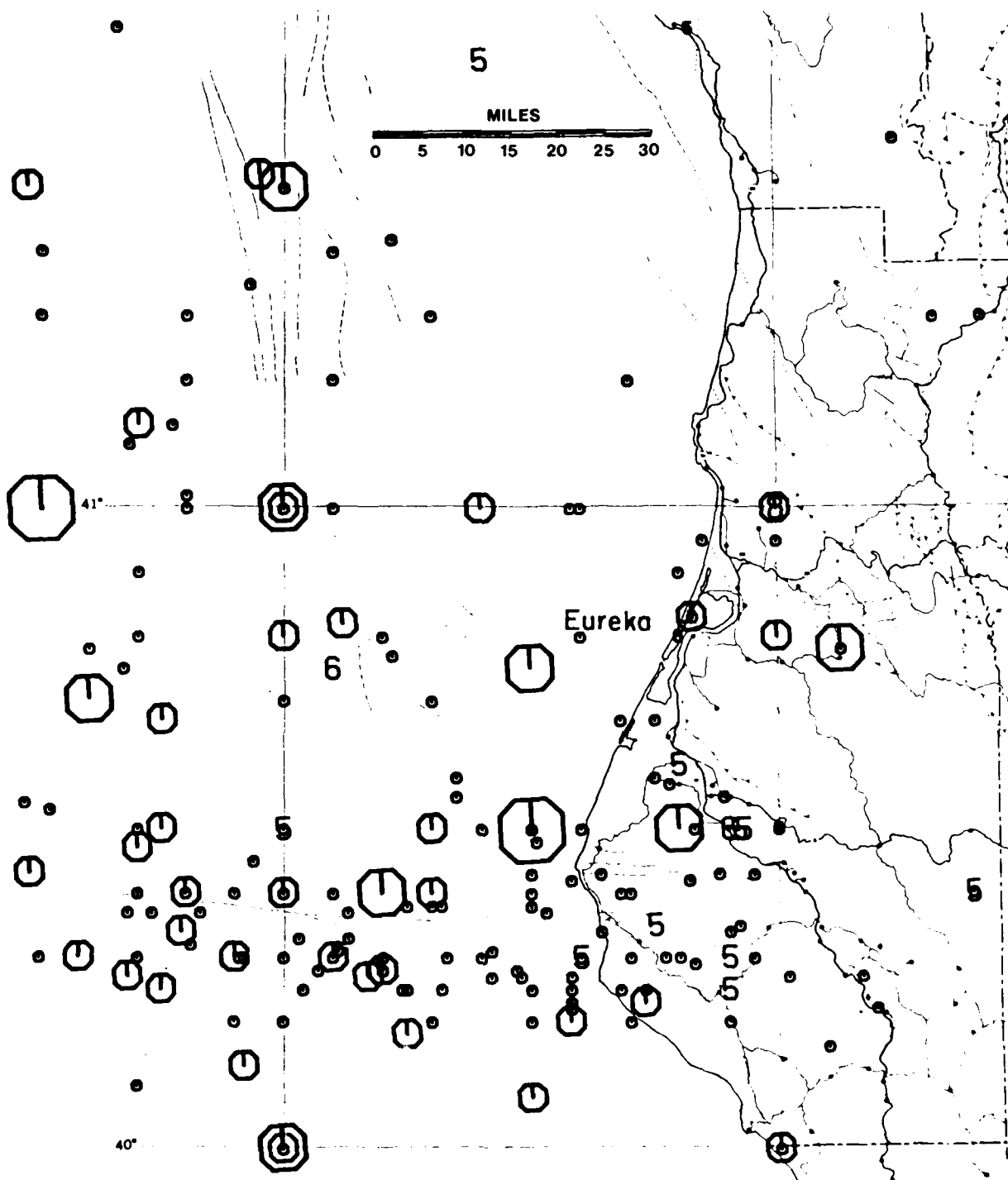
Geologic hazards are naturally occurring processes that could directly or indirectly affect the human environment because of human occupancy of a particularly hazardous area. Damages by natural processes in loss of property and life are increasing, due to pressures of economic growth into hazardous areas and to human alteration of the natural environment. In the Humboldt Bay area, the principal geologic hazards include earthquakes and associated effects, floods, landslides, and erosion. Seismic hazards include damage to structures and potential loss of life primarily as a result of ground shaking. Secondary effects of ground shaking may include liquefaction, settlement, landslides, tsunamis, and seiches. Structures located adjacent to the waterfront, streams, and in low-lying areas are prone to flood hazards. After a prolonged rainfall, especially when the water table is high and during periods of high tide, the soil absorption rate and discharge capacity of the streams are reduced, causing floods. Saturated soil conditions and ground vibrations can trigger landslides. However, landslides also occur due to slope gradient and the nature of the underlying ground material, and a slope may even fail during the dry summer months without ground vibration from earthquakes. Erosion of the soil, stream banks, and shorelines have been accelerated over natural conditions from land use changes to agriculture, forestation, and urbanization.

SEISMIC HAZARDS

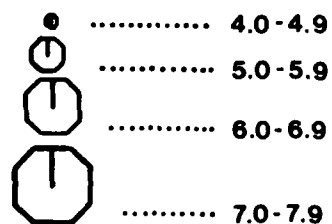
Cape Mendocino is one of the most seismically active areas of California, and has been the location of several damaging earthquakes in the Humboldt Bay area during the past century. Since earthquakes do not seem to occur with a regular periodicity, future earthquakes and magnitudes cannot be accurately predicted. However, from past events and a knowledge of the regional tectonic framework, expected frequencies can be estimated. Evidence indicates that areas of historically high seismicity are areas where damaging earthquakes will occur in the future.

Figure VI-7 shows epicenters of earthquakes of Richter magnitude 4 and greater, and Modified Mercalli intensities V and greater when the magnitude is unknown, for the period 1900-1974. Magnitude and intensities are the energy and effects, respectively, of a particular earthquake. The epicenters show the location of the earthquake at the earth's surface, vertically above the hypocenter or focus. Earthquake hypocenters in Humboldt County occur in two depth zones: a shallow zone, 0-12 km (0-7.5 miles) and a deep seismic zone, 17-35 km (10.5-22 miles).

Earthquake magnitude is a numerical value that describes the amount of energy released by the earthquake. Magnitude is commonly expressed by the Richter scale, and a one-unit increase of magnitude represents an increase of about 32 times the energy released. Hence, a Richter magnitude 8.0 has over 1,000 times the energy released as a magnitude 6.0.



MAGNITUDE



RICHTER SCALE

INTENSITY

INTEGER REPRESENTS
MAXIMUM REPORTED
MODIFIED MERCALLI SCALE

EPICENTER MAP

1900 - 1974

SOURCE: CDMG MAP SHEET 39

Figure VI-7

The intensity of an earthquake describes the physical effects from ground shaking. The scale used to describe intensity is the Modified Mercalli intensity scale, consisting of 12 categories designated by Roman numerals (Figure VI-8). Intensities are general descriptions of the earthquake's impact at a given location and will vary depending not only on the magnitude of the earthquake, but also on the distance from the epicenter, the nature of the geologic and soil conditions, and the quality of building construction.

Earthquakes result from movement and breaking of rocks along faults, which may or may not break the ground surface. An active fault can be defined by a number of factors. For siting of a nuclear power plant, the Nuclear Regulatory Commission (NRC), formerly the Atomic Energy Commission, defines fault activity as movement at or near the ground surface at least once within the past 35,000 years, or movement of a recurring nature within the past 500,000 years (Atomic Energy Commission, 1973). In the Fault Map of California (Jennings, 1975), the California Division of Mines and Geology has classified three groups of faults, indicating recency of movement: Historic, Quaternary, and Pre-Quaternary. These faults have not been assigned an activity rating; however, Pre-Quaternary faults (older than two million years) that do not have recognized Quaternary displacements are considered inactive. Potentially active faults show geomorphic evidence of Quaternary displacement, such as scarps in alluvium, terraces or other Quaternary units; offset stream courses, or markedly linear steep mountain fronts, etc. Active faults are those that show movement or displacement in Holocene time, or the past 11,000 years. Activity and recurrence for a given earthquake fault can be determined from past earthquake history, the distribution of epicenters, the size of the fault, and the ages of displacements that have occurred during the past several thousand years. Several faults in the Humboldt Bay area that are active and capable of producing damaging earthquakes are discussed below.

Faults

Descriptions of faults, patterns of seismicity, and their capabilities in the Humboldt Bay area have been discussed in detail by ENVICOM, 1975; ESA, 1975 and 1977; and Smith, 1975. Locations of these faults are shown in Plate 4 and Figure VI-5, and a summary of fault descriptions is included in Table VI-2. The faults that are active and that should be considered for seismic designs are: the Deep Seismic Zone; the San Andreas-Mendocino System; and the Mad River Zone, including the Falor and Korbelt Faults. Each of these fault systems was examined based on the size of the fault, patterns of seismicity, the depth of occurrence, and other geologic conditions to estimate the maximum possible earthquake that might occur. Other faults that are potentially active in the Humboldt Bay area comprise the Little Salmon-Bay Entrance fault zone. The data concerning the relationships of the faults within this zone are presently inconclusive.

Figure VI-8

MODIFIED MERCALLI INTENSITY SCALE

- I. Not felt except by a very few under especially favorable circumstances.
- II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
- III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.
- IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
- V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop.
- VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
- VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
- VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbs persons driving motor cars.
- IX. Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
- X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with their foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
- XI. Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
- XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

Table VI-2

HUMBOLDT BAY FAULT INFORMATION

Fault or Zone	Description	Structural Relationship	Seismicity	Activity
Deep Seismic Zone	Well-defined zone located 17 to 35 km deep. Consists of NE-trending fault-like features without surface expression.	Considered to be remnant of the Gorda Plate (ocean floor) thrust under continent several million years ago.	June 7, 1975, M 5.5 Nov. 14, 1975, M 4.9	Active
San Andreas	NW-trending strike-slip fault, northern segment 240 miles long, several hundred to a few thousand feet wide.	California's most prominent fault; bends westerly at Cape Mendocino.	Apr. 18, 1906, M 8.3 Felt in Humboldt County I: VIII & IX.	Active
Mendocino System includes Russ fault-False Cape shear zone	NW to W-trending up to 60 miles long onshore and 300 miles offshore, 20 miles wide onshore.	Most seismically active area in North America. Related to plate tectonics.	Jan. 22, 1923, M 7.2 on trend offshore, high level of microseismic activity.	Active
Mad River Zone includes Falor, Korbelt faults	NW-trending normal and strike-slip, greater than 40 miles long.	NW-trending fault system parallel to regional fabric, may extend offshore.	Probable source of Dec. 21, 1954, M 6.5 and aftershocks.	Active
Little Salmon-Yager fault	NW to N-trending, NE to E dipping thrust fault 34 miles long.	May be related to older structural features, No evidence for Holocene displacements	No historic earthquakes, may include seismically active zone.	Potentially Active (Quaternary)
Table Bluff	NW-trending, NE-dipping, steep reverse fault, 15 miles long	Possible branch to Little Salmon-Yager.	No historic earthquakes.	Potentially Active (Quaternary)

Table VI-2 (Continued)

HUMBOLDT BAY FAULT INFORMATION

Fault or Zone	Description	Structural Relationship	Seismicity	Activity
Bay Entrance	N-trending, near vertical reverse fault, 6 miles long.	Probable association with Little Salmon, minimum length 35 miles.	Sept. 20, 1976, M 3.0, 3.2	Potentially Active
North Spit	N-trending, near vertical fault, 15 miles long.	Possibly offsets ocean floor.	Seismicity in Elk River valley indicates possible extension of this fault	Potentially Active
Freshwater	NW-trending vertical fault, 35 miles long.	Offset by Little Salmon-Yager fault.	Several earthquakes instrumentally located near fault	Inactive

Source: ESA, 1975; Smith, 1975; Morris, 1977.

Deep Seismic Zone

Seismic evidence indicates that earthquakes occur in a well-defined zone along numerous fault-like structures which have no apparent surface expression. This zone, located from 17 to 35 km (10.5 to 22 miles) deep, is interpreted to be a remnant of the Pacific Ocean (Gorda Plate) that was thrust beneath the continent several million years ago (Smith, 1975). This zone is active and capable of producing a maximum earthquake of magnitude 6.1 (Smith, 1975). The Ferndale earthquake of June 7, 1975, magnitude 5.5, originated in this zone.

San Andreas-Mendocino System

The San Andreas is a northwest-trending strike-slip fault. Evidence suggests that it does not continue northward beyond Cape Mendocino, but rather bends westward and joins the Mendocino fault zone (Figure VI-5). Eureka and the Humboldt Bay area suffered damages to structures (intensities VIII and IX) and experienced numerous soil failures from the 1906 San Francisco earthquake (Lawson, 1908). The Mendocino fracture zone may extend eastward on land as expressed by the numerous shear zones, such as the Russ fault-False Cape shear zone and the Mattole fault shear zone (Figure VI-5). The San Andreas-Mendocino system has active faults capable of producing a magnitude 8.3 earthquake or one with intensities comparable to the 1906 San Francisco event.

Mad River Fault Zone

The Mad River fault zone, including the Falor and Korbelt faults, consists of northwest-trending high-angle normal and reverse faults (see Surface Rupture for description of fault types). Evidence from surface geomorphic expression and focal mechanisms from several earthquakes in the region indicate that these faults are active. This system is the likely source for the December 1954 magnitude 6.5 earthquake in Humboldt County, based on isoseismal distribution (areas of equal intensities) and aftershock patterns. A maximum credible earthquake of magnitude 7.0 is considered conservative for this zone (Smith, 1975). Herd (1978) describes the McKinleyville fault zone (correlative to the Mad River zone) as a zone of active faulting that extends offshore towards Trinidad Head and southwest of Crescent City and is the northward continuation of a line of faults (Hayward-Lake Mountain fault system) that diverges from and parallels the San Andreas fault zone north from Hollister.

Other Faults

Other faults within the Humboldt Bay area that are potentially active include the Bay Entrance, North Spit, Table Bluff, and Little Salmon-Yager faults. These faults have been studied intensively (ESA, 1975 and 1977). ESA (1975) indicates that the Little Salmon-Yager fault is inactive. Further studies are required to clarify the relationships and the recent geologic and tectonic history of this fault zone to the regional tectonic setting. However, Morris (1977) questions the analysis of fault activity assigned to

the faults in the vicinity of the Humboldt Nuclear Power Plant by ESA. Morris suggests that since the Mad River fault zone and the Russ fault-False Cape shear zone are active and controlled by the regional tectonic north-south compressional stresses, then "it appears unlikely that the Little Salmon fault can remain inactive while faults on either side under the same stress field are active."

Faults in the Arcata area (Moring, 1976), along the Mad River (Carver, 1979), and the Fickle Hill fault are considered potentially active and may be associated with the Mad River fault zone (Plate 4). The Freshwater fault is inactive. It has juxtaposed the Yager Formation against the Franciscan Formation, but has not offset the overlying Hookton Formation.

New data from age dating techniques, including paleomagnetic, biostratigraphic, and radioactive isotopes, indicate that the Wildcat sedimentary units are younger than previously recognized. It is believed, based on these age dating procedures, that the Scotia Bluffs Formation at Centerville Beach is less than 700,000 years old, compared to the Upper Pliocene (2-3 million years) age assigned by Ogle, 1953. This problem is further complicated in that these formational units are time-transgressive; that is, the same sedimentary unit becomes progressively older towards the east. Age determinations of the formational units within the Humboldt Bay area would provide a datum on which to establish maximum ages of faulting and would indicate an inactive or potentially active fault based on the latest movement of offset sediments.

Effects of Earthquakes

Recognizing that active and potentially active faults exist in the Humboldt Bay area, it is important to know what can happen during an earthquake, and how to best minimize potential damages. Ground shaking and surface rupture are the primary effects of an earthquake. Secondary effects of ground shaking depend on local geologic characteristics and may include liquefaction, lurch cracking, settlement, landsliding, tsunamis, and seiches. The following discussion on the effects of earthquakes has been adapted primarily from USGS Professional Paper 941-A and CDMG Special Report 97, on studies for the San Francisco Bay Region.

Ground Shaking

Shock waves are generated along a fault and travel through rock materials, causing the ground to vibrate. The intensity of ground shaking is primarily dependent on the magnitude and duration of the earthquake, the distance from the fault, and the local geology. Damages sustained by a structure are largely a function of the building design and the material on which it is built. Shock waves traveling through less dense materials tend to decrease in velocity, and

increase in amplitude. Accelerations become greater and ground motion lasts longer. Therefore, structures located on less dense material such as alluvial and water-saturated sediments generally suffer far greater damages than structures located on solid rock.

Surface Rupture

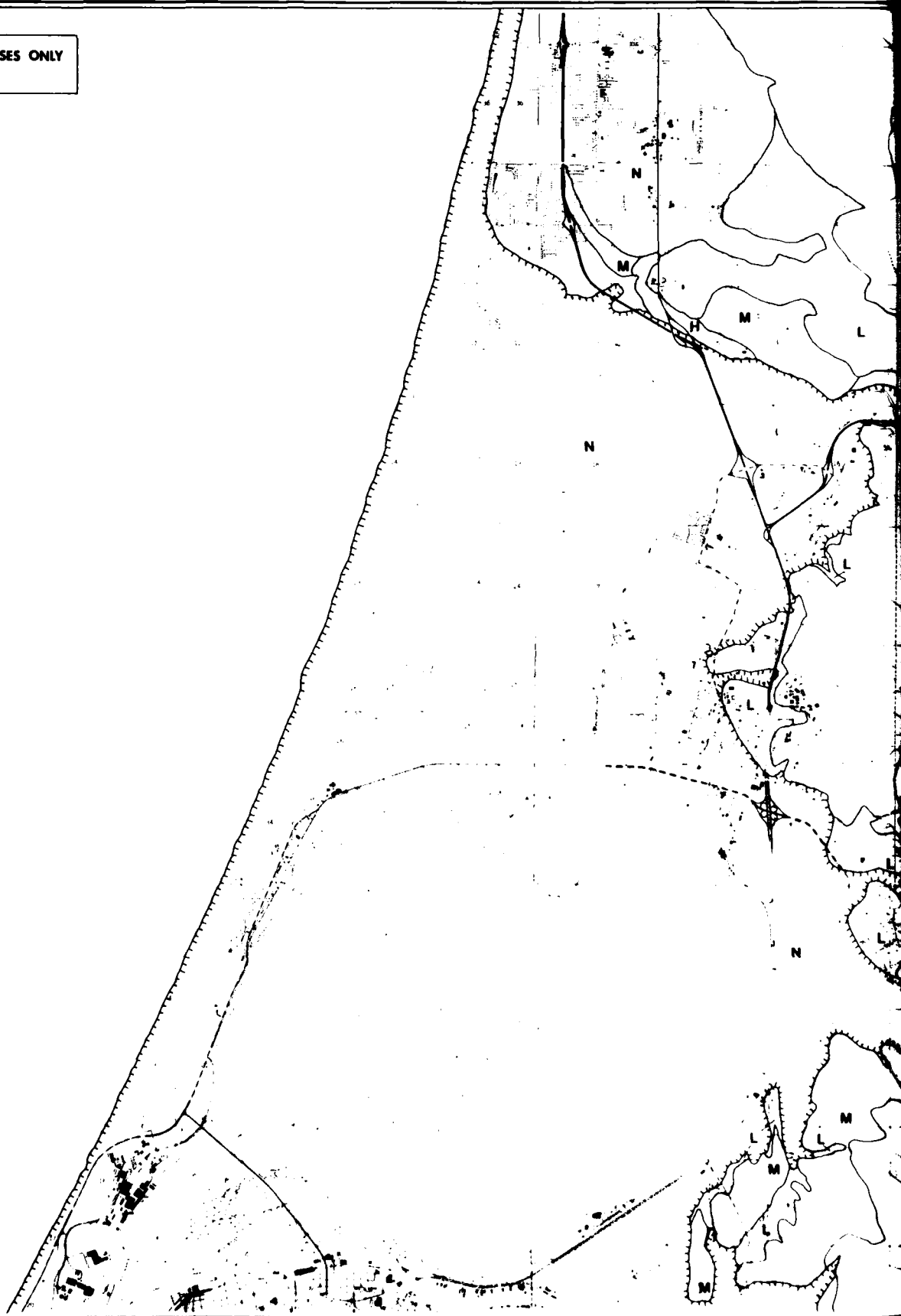
Movement along a fault plane may break the ground surface. The amount and type of surface rupture is dependent on the type of fault and may be vertical, horizontal, or oblique. Strike-slip or horizontal movement which is typical of the San Andreas fault, is potentially less damaging than a normal or reverse fault which would produce vertical offsets. The San Andreas fault, in the 1906 magnitude 8.3 earthquake had a maximum of 20 feet of horizontal movement near Tomales Bay with considerable surface rupture along the fault break, while from the 1957 magnitude 5.3 earthquake near San Francisco, there was no surface rupture. The 1971 San Fernando magnitude 6.6 earthquake, resulted in extensive damage largely because it had reverse, or vertical offset. The Mad River fault zone is considered capable of producing an earthquake similar to the San Fernando event (Smith, 1975) and possibly greater, with a maximum credible earthquake of magnitude 7. Faulting can also disturb natural and artificial drainage features and change the characteristics of springs and groundwater flow.

Liquefaction

Liquefaction is defined as the transformation of granular material from a solid state into a liquefied state as a consequence of increased pore-water pressure (Youd, 1973). This transformation is most likely in saturated, unconsolidated sedimentary deposits in a seismically active area. Some portions of the Humboldt Bay area meet these requisites.

Liquefaction potential is dependent on the soil type and its relative density, the intensity and duration of ground vibration, and the depths of the water table. Based on studies from the San Francisco Bay region, deposits can be rated as having a high, moderate, or low potential for liquefaction. Low potential sedimentary deposits include Pleistocene gravels and sands (Hookton Formation), which are weathered, have a higher density, and are more consolidated. Holocene alluvial deposits are generally unweathered, wetter, looser and less consolidated, and therefore have a higher (moderate) potential for liquefaction. Clay-free granular bay sands have the highest potential for liquefaction. Areas that have potential for liquefaction are indicated in Plate 5. It should be noted that liquefaction potential can be generally expected within this area, but at some sites the potential can be very low. Detailed soils engineering and geologic investigations are necessary, however, to evaluate the potential for liquefaction on a site-specific basis.

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GROUND FAILURE HAZARD ZONES

PLATE NO 5 NORTH

LEGEND

Slope Instability

N Negligible

L Low

M Moderate

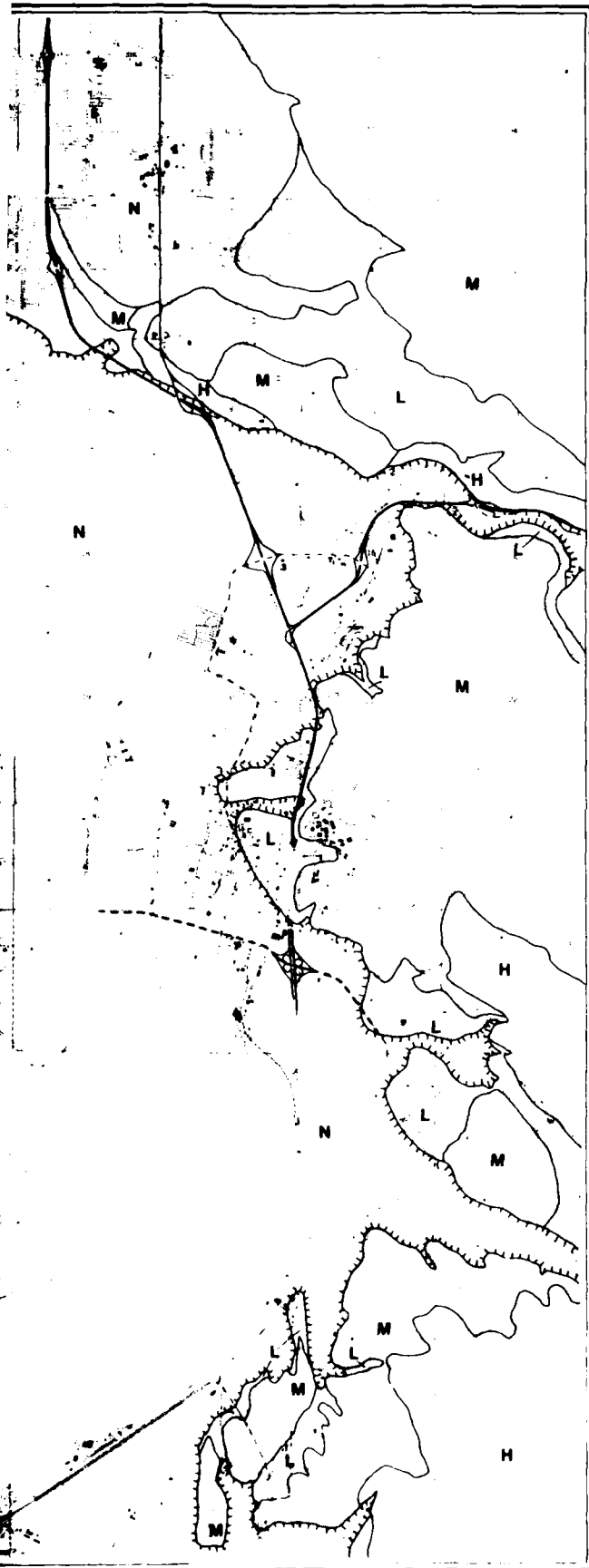
H High

 Liquefaction Hazard

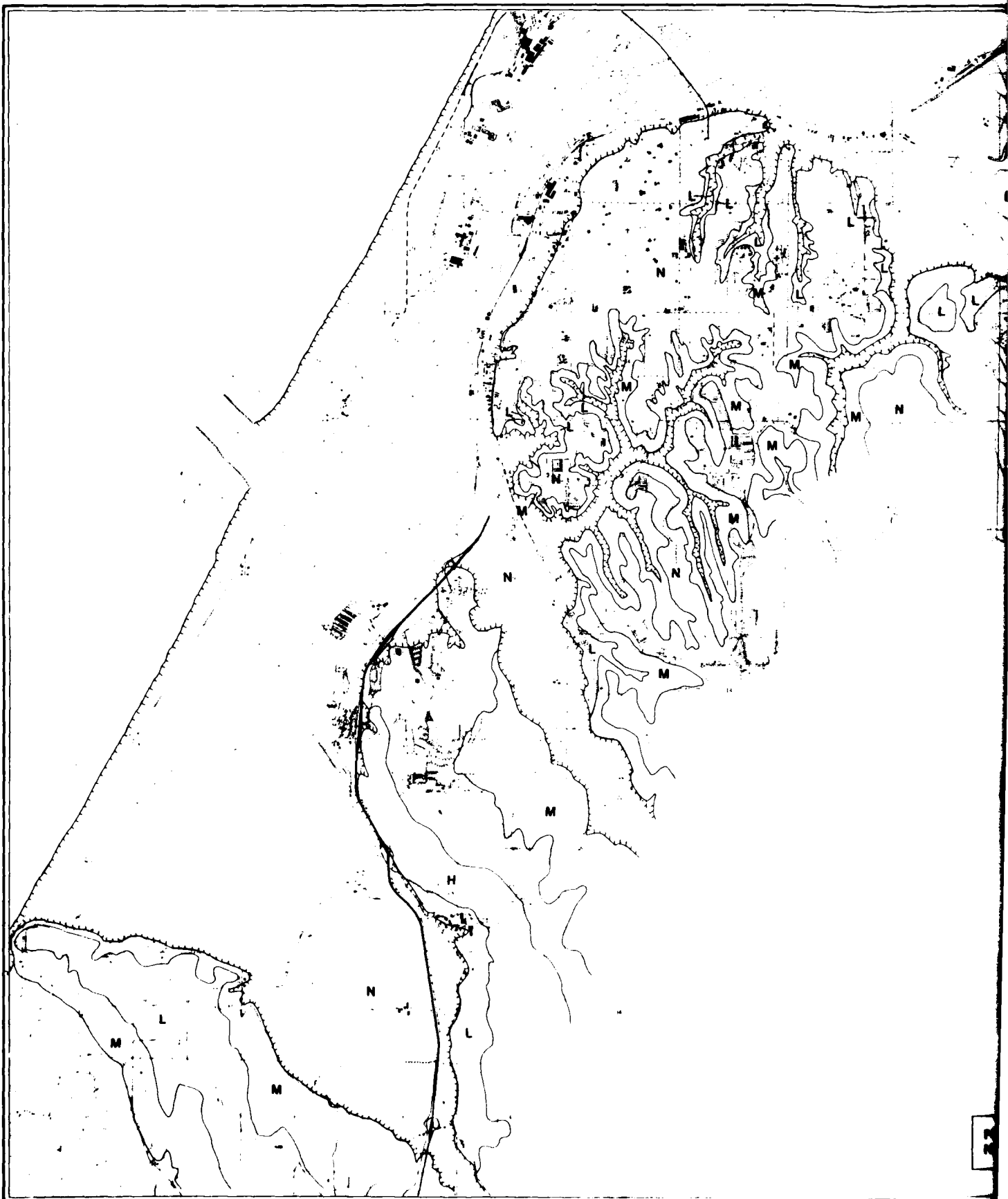


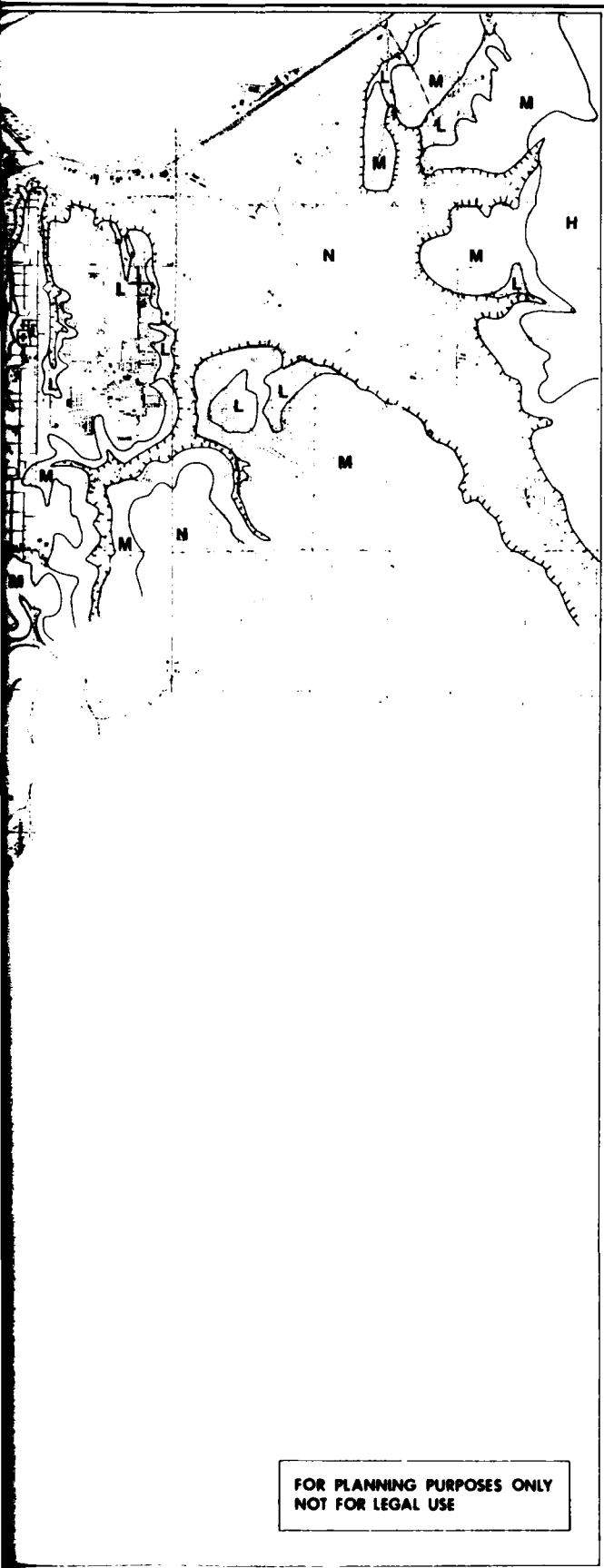
HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: City of Eureka Dept of Community
Development 1975



1 2





GROUND FAILURE HAZARD ZONES

PLATE NO 5 SOUTH

LEGEND

Slope Instability

N Negligible

L Low

M Moderate

H High

 Liquefaction Hazard



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: City of Eureka Department of Community
Development 1975

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When loose granular sands are subjected to ground vibrations from earthquakes, an increase in pore pressure occurs, resulting in movement of water to the ground surface. The development of high water pressure tends to turn the soil into a "quick" or liquefied state. As liquefaction develops, automobiles, structures, and other objects gradually settle into the resulting quicksand, and lightweight buried objects tend to float to the surface. If liquefaction occurs on a gently sloping surface, the entire soil mass will tend to flow or move laterally with resultant cracks, fissures, and differential settlement.

Lurch Cracking

Lurch cracking produces complex patterns of cracks and fissures in the ground surface due to moderate and large sized earthquakes (magnitudes 6 to 8). Extensive and damaging lurch cracking, often associated with liquefaction, occurs in water-saturated materials. Displacements in weathered alluvium and soils may be horizontal or vertical, and may produce cracks many tens of feet long. Vertical displacements of 2 to 3 feet in the Ferndale Bottoms resulted from the 1906 San Francisco earthquake (Lawson, 1908). Lurch cracking in bay muds and fill could result in extensive damages to areas in or near the bay, such as occurred in the San Francisco waterfront areas in 1906.

Settlement

Settlement of natural, rapidly deposited sedimentary material and improperly placed artificial fills occurs from long-term stress due to loading by roads and structures or by compaction during earthquake vibrations. Differential settlement in buildings, where one portion settles more than another, can cause strains that substantially weaken the structure. Many buildings in the Eureka "old town" district show signs of distress. Continual problems of settlement and subsidence of filled land are occurring at King Salmon and Fields Landing. During an earthquake, serious structural damage could result from additional compaction and settlement due to nonuniform soil or fill conditions. Flooding, due to settlement, could occur in the low lying areas near the bay.

Landsliding

Landslides are a common result of ground shaking from earthquakes of magnitude 5 and greater. The landslide that damaged part of the Northwestern Pacific Railroad trestle and blocked the tracks near Rio Dell resulted from the June 7, 1975 magnitude 5.5 earthquake. Numerous geologically-recent slides, many of them highly unstable, mark the hillslopes between Fields Landing and College of the Redwoods, and along the Mad River fault zone. Slope instability is the result

of many natural conditions and these are discussed in the following section (Landslides).

Tsunamis

Tsunamis, or "tidal waves," are large water waves generated in the ocean by fault displacements or other abrupt ground movements on the sea floor. In the open ocean, tsunamis travel at speeds of 300 to 500 miles per hour, and may have wave lengths of many miles. As it approaches shore, the height of a wave increases rapidly, depending on offshore topography, tidal phase, coastline orientation and configuration. It may reach tens of feet in height.

Tsunamis from the 1960 Chilean earthquake and the 1964 Alaska earthquake affected the California coast. General reports indicate that these tsunamis were similar to tides, but with greater accelerated vertical movement and horizontal currents (Magoon, 1965). The 1964 tsunami, which had a greater impact than the 1960 tsunami in Northern California, resulted in over \$11 million damage and claimed 11 lives in Crescent City (Wilson and Torum, 1968; Tudor, 1974). Most damage occurred to commercial fishing or pleasure craft and associated shore facilities, as a result of unusually swift currents and battering from loose debris, such as logs and stumps. At Humboldt Bay the effects of the 1964 tsunami were not as destructive to shore facilities. Maximum water levels recorded within the bay at the Coast Guard station and at the Municipal Marina were 9 feet and 12.4 feet above MLLW, respectively. The tsunami resulted in currents estimated at 14 knots and a 6 foot change of water level in about 20 minutes in the Samoa Channel (Magoon, 1965). Maximum wave height reported was 12 feet.

Runup elevations from tsunamis of distant origin, for most of the western United States coastline, were determined for 100 and 500 year occurrences (Houston, 1978). Calculation of these elevations was based on historical data, using numerical models that propagated tsunamis across the deep-ocean and into the nearshore region. These data indicate that the Humboldt Bay Entrance channel can expect elevations of approximately 11 and 21 feet above mean sea level for the 100 and 500 year runups, respectively. These are maximum elevations that include the astronomical effect of tides.

Seiches

A seiche is an oscillation, or sloshing back and forth, of the surface water in an enclosed or semi-enclosed basin. Its period is controlled by the length and depth of the containing basin. Seiches are initiated chiefly by local changes in atmospheric pressure, aided by wind and currents. The terminology was first applied to standing waves set up on Lake Geneva by these conditions. Seiches set up on rivers, reservoirs, ponds, and lakes can also occur due to passage of seismic waves from an earthquake. These are termed seismic seiches.

Seiches can also be caused by other mechanisms such as landslides, submarine slides, tilting, and tsunamis.

Seiches vary in period from several minutes to several hours and in height from several centimeters to a few meters. Seismic seiches can result from distant as well as local earthquakes. The March 27, 1964 Alaska earthquake caused a seiche in Michigan that had an amplitude of 1.83 feet, and in California the maximum resulting from this event was .42 feet in the Salinas reservoir (McGarr and Vorhis, 1968). However, larger seiches have been generated at Hegben Lake, Montana, as a result of the 1954 earthquake and landslide.

In some estuaries the periodic flooding by the tides is supplemented by seiches. The natural period of the seiche nearly coincides with that of the tide and, as at the Bay of Fundy, fluctuations up to 15 meters in sea level occurs. However, in most estuaries, the seiche is only a few centimeters high and is obscured by the much greater tidal amplitude.

Due to the tectonic setting, winds, and tidal influences, the potential for developing seiches within Humboldt Bay exists. The hazard is not considered to be significant, based on past records; however, additional studies may be necessary.

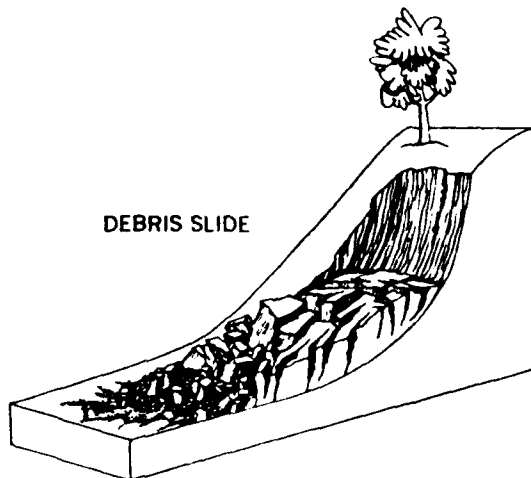
LANDSLIDES

Landslides are characteristically abundant in areas of high seismicity, high rainfall, and steep slopes. These factors act as triggering mechanisms for landslides, but are not the only causes of slope instability. Identification of areas susceptible to slope failure requires understanding of all factors that contribute to the slope failure process and detailed investigations of specific site characteristics.

Common landslide types, shown in Figure VI-9, are debris slide, earthflow, slump, and rockfall, all of which occur in Humboldt County. The scale of slides can range from small slips less than a foot deep to large-scale debris slides involving entire hillsides and incorporating many hundreds of cubic yards of earth. The differences in landslide types reflect the differences in physical conditions characteristic of the site. These controlling factors in landslide occurrence and development are: types and structural properties of the earth material, water content, type of vegetative cover over the area, and slope gradient, especially slopes undercut by stream erosion or earth removed for roads or other constructional purposes. Many of these factors are interrelated and increase the susceptibility of the potential hazard.

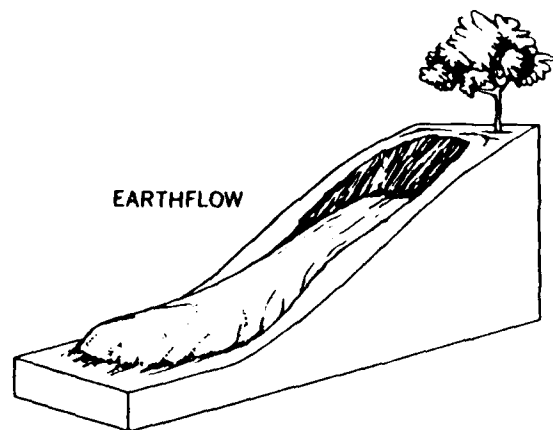
Figure VI- 9

COMMON TYPES OF LANDSLIDES



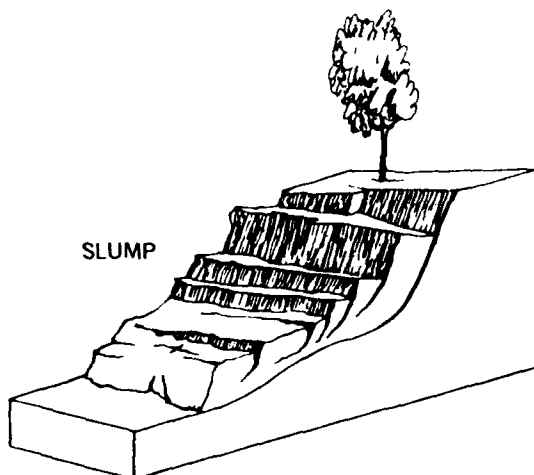
DEBRIS SLIDE

Incoherent or broken masses of rock and other debris that move downslope by sliding on a surface that underlies the deposit



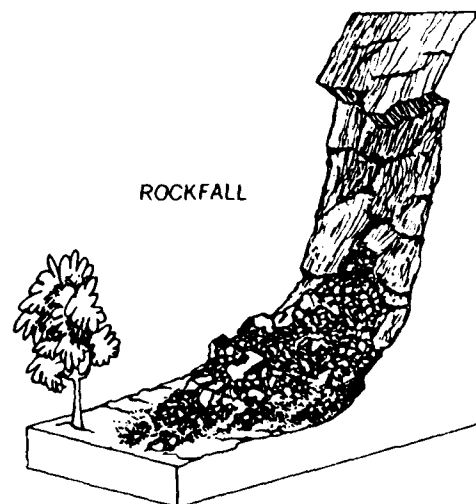
EARTHFLOW

Colluvial materials that move downslope in a manner similar to a viscous fluid



SLUMP

Coherent or intact masses that move downslope by rotational slip on surfaces that underlie as well as penetrate the landslide deposit



ROCKFALL

Rock that has moved primarily by falling through the air

Source: Geological Survey Prof. Paper, 941-A.

Plate 5 depicts the risk categories of potential landslide hazard based chiefly on rock types and slope gradient (Eureka, 1975). This evaluation is intended as a guide for land use planning and should not be considered as a substitute for the soils engineering geologic evaluation of a specific site.

Generally, areas of steep slopes, underlain by the Franciscan and Wildcat Formations are in the high risk category. These units are structurally complex, generally have deep weathered soils and a high water content. Landsliding is more frequent in areas of saturated soil conditions because water commonly decreases the cohesive forces, lubricates surfaces along which slippage occurs, adds weight to surficial deposits, and mixes with finer grained unconsolidated material to produce wet unstable slurries.

Areas with a moderate risk rating are generally underlain by the Hookton Formation and marine terrace deposits. These deposits are generally flat lying and well drained. However, where steep slopes are encountered that have been undercut by erosion in the stream valleys and gulches or in areas of known faults, slumps and debris slides are likely to occur.

Low risk areas include slopes between 5 and 15 percent underlain by Late Pleistocene fluvial and marine deposits, and some gently sloping areas of the Hookton Formation. Although not subject to massive failures, these areas are prone to slumping along stream channels and road cuts.

Negligible landslide risk areas have slopes less than 5% and chiefly comprise the alluvial valleys of the Mad River, Jacoby Creek, Freshwater Creek, Elk River, and Salmon Creek. Slumping of bankside material occurs from erosion processes along these streams.

FLOOD HAZARD

Flood hazard in the Humboldt Bay area results primarily from prolonged periods of intense rainfall causing overbank flooding from rivers and streams. Minor flooding occurs from storm water runoff without overbank flooding, and results in standing water up to 2 feet deep in low depressions such as old meander scars on the Arcata Bottoms. Flooding of the coastal areas by tsunamis is discussed under secondary seismic hazards.

The Humboldt Bay area is subject to severe winter storms. Most of the flooding occurs when the amount of runoff from a watershed exceeds the capacity of the stream draining that watershed. The mountainous characteristics of steep slopes in the drainage basins, including the Mad and Elk Rivers, Freshwater and Jacoby Creeks, and other smaller creeks, cause rapid concentration and runoff into the

main streams, resulting in frequent overbank flooding. Other factors that affect the amount of runoff include the rate and duration of rainfall, nature of the vegetation, absorption capacity of the soil, and the amount of snow. The river channel capacities in these areas are inadequate, and damage from erosion and overbank flooding of the stream banks occurs. The flood problem is aggravated by the large amounts of debris and sediment carried by these streams.

The most extensive flood damage in the Humboldt Bay area occurred from overbank flooding of the Mad River during the December 1955 and December 1964 storms. The December 1955 event had the largest peak discharge at the Arcata gauge, 77,800 cubic feet per second (cfs). The peak discharge for the December 1964 event was about 10% less than in December 1955. However, the two-day maximum volume of runoff in December 1964 exceeded that of December 1955 by about 25%.

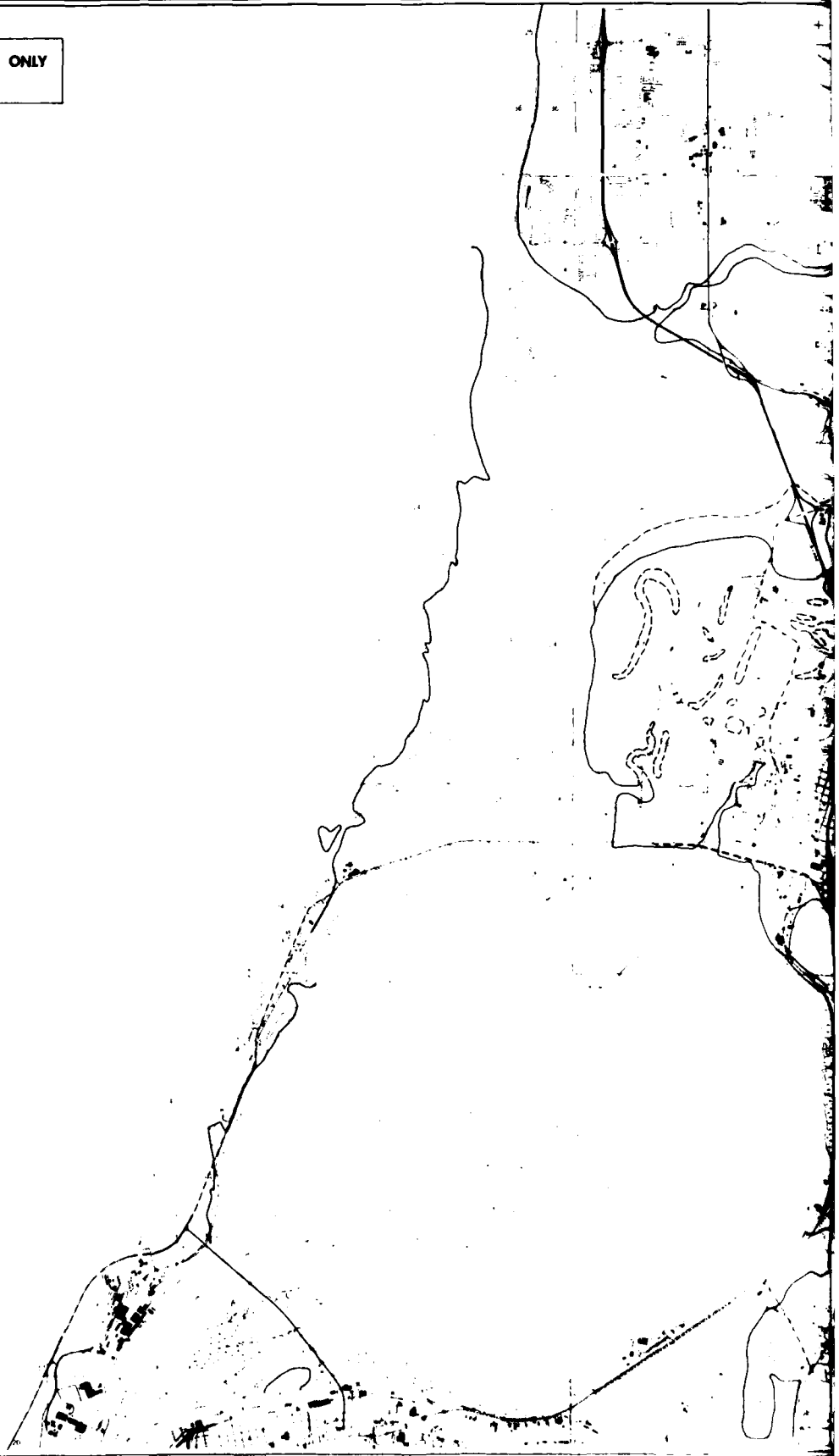
The flood frequency analysis for the Mad River for storm events equivalent to those of December 1955 and December 1964 has been prepared by the Corps of Engineers (1968). The flood frequency or recurrence interval is the average time span between natural events of a given size. The December 1955 flood is estimated to have a 4% frequency of annual exceedence with respect to peak discharge and volume discharge. The December 1964 flood is estimated to have a 5% frequency of annual exceedence with respect to peak discharge, and a 2% frequency of annual exceedence with respect to volume discharge.

The standard project flood determined for the Mad River and the extent of the area inundated near Arcata correspond to the 100-year floodplain shown in Plate 6. The standard project flood is a major flood that can be expected to occur from the most severe combination of meteorological and hydrological conditions reasonably characteristic of the geographic region, excluding extremely rare conditions. The estimated peak discharge of the standard project flood for the Mad River is estimated at 132,000 cfs, which exceeds the maximum on record by approximately 70% (COE, 1968).

The floodplain designation shown in Plate 6 was determined by the U.S. Geological Survey to delineate the areas which are subject to inundation within the 100 year flood interval. This federal demarcation is required for communities that participate in the U.S. Department of Housing and Urban Development (HUD) National Flood Insurance Program and is a refinement of the preliminary HUD flood zone maps of the Humboldt Bay area.

The March 1975 storm caused extensive flooding of the low-lying areas adjacent to Humboldt Bay, but did not produce peak discharge volumes that exceeded the capacity of the Mad River at Arcata. The limits of this storm were mapped by the County Planning Department from aerial and ground observations and show that the flooded areas closely corresponded to the 100 year floodplain designated from the

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FLOOD HAZARDS

PLATE NO 6 NORTH

LEGEND

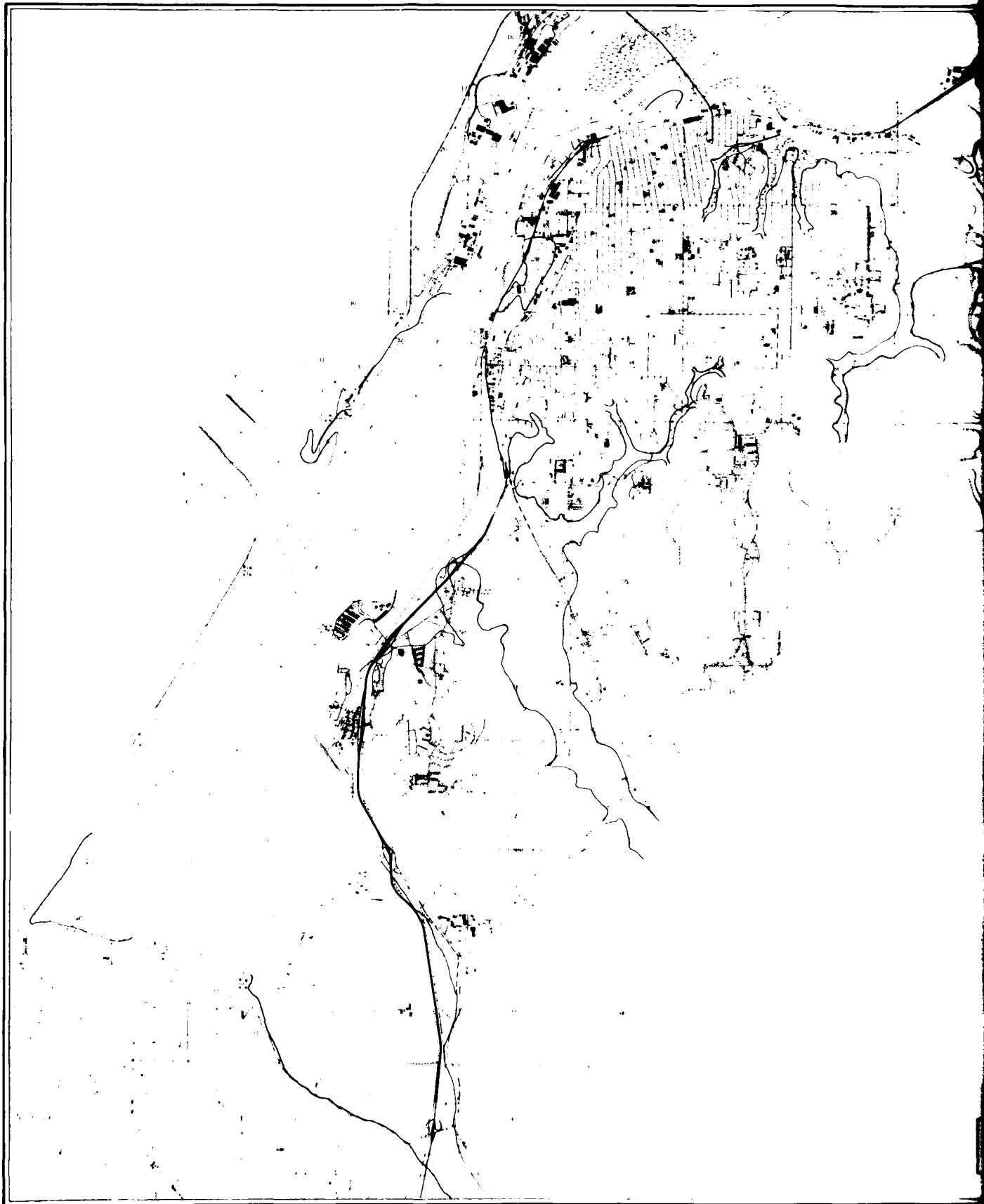
- 100 Year Flood Hazard Area
- - - Extent March 1975 Flood

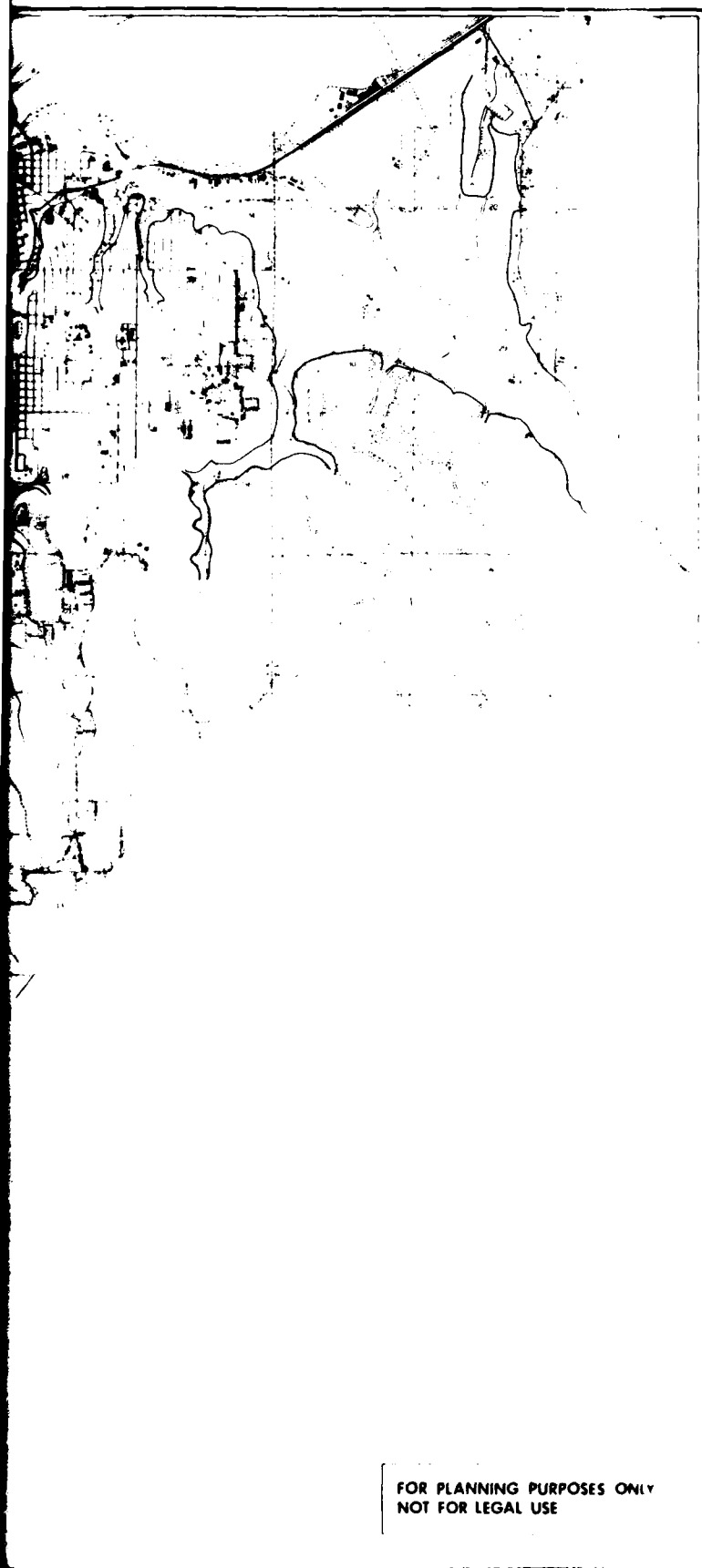


HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: U.S. Geological Survey







FLOOD HAZARDS

PLATE NO 6 SOUTH

LEGEND

- 100 Year Flood Hazard Area
- - - Extent March 1975 Flood



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: U S Geological Survey

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U.S. Geological Survey Flood Hazard Map (Plate 6). This localized flooding occurred as a result of intense rainfall in the Humboldt Bay watershed and high tides. Data from the National Weather Service station at Eureka reported 4.82 inches of rainfall for the two-day period, March 17 and 18, 1975. In comparison, rainfall at Eureka during the December 1964 storm was less than one inch per day for the four-day period. However, the mountainous regions in the upper watersheds of the Smith, Klamath, Mad, and Eel Rivers received from 3 to 8 inches of rainfall per day during the four-day period of the 1964 storm.

The characteristics of the lowlands adjacent to Humboldt Bay combine to create a high potential for flood hazard even with moderate rainfall intensities. Abandoned meander scars and blocked natural drainages are particularly vulnerable to flooding from the high water table, tidal influences, and the low percolation capabilities of the soil. Damages to personal property will tend to increase as residential and commercial development expands into these areas.

EROSION

As a result of poor practices in cultivation, burning, grazing, logging, and road building or other urban developments, favorable conditions for accelerated erosion are created. Human-induced erosion proceeds rapidly when compared to the slow, non-human induced, geologic erosion. Geologic erosion is generally recognized as the gradual wearing away of the land surface by the action of water, wind, and gravity. Induced erosion is the result of the disturbance or modification of the natural conditions and can result in the loss of topsoil and lower soil fertility, aggradation of lower stream reaches, rapid sedimentation of reservoirs, and increased flood damage.

Intensive agricultural practices and overgrazing have led to erosion of the Hookton and Rohnerville soils on the upland terraces. On these gently sloping to steep terraces, from 6 to 30 inches of soil have been lost or moved downslope by erosion (SCS, 1967). Plowing should occur prior to commencement of the rainy season and consideration should be given as to the direction of plowing if erosion is to be avoided. Overgrazing will not usually destroy the plant roots that provide stabilization of the soil mass, however to prevent soil loss, protection above ground is needed (McLaughlin and Harradine, 1965).

The most widely recognized effect of induced erosion has been degradation of the watersheds; a direct result of timber harvesting and road building in forested areas. Removal of the forest canopy and vegetation cover exposes the soil surface allowing an increase in the rate of storm water runoff and decreasing the absorption capacity of the soil. Increased surface runoff can result in

accelerated erosion. Dry-sliding can also occur under the influence of gravity on steep slopes. These eroded sediments are transported downslope and downstream, and can cause aggradation of the river channel, resulting in lateral migration of the stream, initiating bank scour and landsliding that further contributes sediment loads. This process resulted in the sediment infilling of Sweasy Dam on the Mad River. Deposition of sediment has deteriorated some of the potential rearing and spawning habitats for salmonids that utilize the streams of Humboldt Bay (see Fish). Sediment infilling of rivers and streams and increased storm runoff greatly increases the flood potential to the lower reaches of the rivers.

Certain areas within Humboldt Bay have undergone significant changes in coastal configuration in the last 100 years. Extensive erosion and accretion in the Entrance Channel-Buhne Point area (Figure VI-9a) is presently under study to determine the causative factors. The significant changes that have occurred in this area include: the erosion of Buhne Point and deepening of the offshore area, the formation and accretion of the Elk River Spit, and the accretion of North and South Spits. The erosion and accretion that have occurred in these areas are due to the action of waves and tidal currents.

The erosion of Buhne Point and area to the north up to the Elk River Spit has receded from 600 to 1,600 feet during the period 1854 to 1955 (COE, 1956). The rate of this erosion has not been constant through this time period, but varied from approximately 5.5 feet per year between 1854 and 1926, and 46 feet per year during 1926 to 1955.

Surveys of the formation and advancement of Elk River Spit indicate that the river mouth had shifted from the north side of the spit in 1854 to the south side of the spit as indicated in the 1870 survey. By the time of the 1911 survey, a new spit developed on the south side of the mouth of Elk River and in the period 1929 to 1955 that spit advanced in a northerly direction approximately 4,200 feet.

The major changes that have occurred to the offshore area have been the shoreward movement of the 6 foot depth contour in the vicinity of Buhne Point and a general bayward movement of the depth contours accompanying the growth and advance of Elk River Spit. Erosion of the foreshore and nearshore area and scour of up to 13 feet in the offshore area have been the predominant changes in the Buhne Point area. Filling or shoaling of the bay up to 37 feet has occurred along what is now Elk River Spit. In the bayward area adjacent to the spit, readjustment of the bottom profile has resulted in 22 feet of filling in a deep channel and about 11 feet of scour adjacent to that channel. Adjustment of the slope between the Elk River Spit area and Buhne Point area has resulted in net scour.

Surveys by the Coast and Geodetic Survey and by the Corps of Engineers indicate that net seaward advance of the high water shoreline of both the north and south spit occurred as a result of jetty construction (COE, 1950). These changes are shown in Figure VI-9a, and summarized as follows.

Prior to construction of the jetties, alternate accretion and erosion of the spits at the entrance channel resulted in no significant change in the position of the shoreline during the period 1854 and 1870. Jetty construction commenced in 1890. The net change in the position of the shoreline, during the period 1870 to 1940, was a seaward shift of both the north and South Spit shorelines. A seaward shift of 3,400 feet occurred along the North Spit shoreline adjacent to North Jetty. Similarly, 2,600 feet of seaward advance occurred adjacent to the South Spit Jetty during the same time period (Figure VI-9a). This movement resulted in an accretionary wedge for a distance of approximately 3 miles for the North Spit and 3.5 miles for the South Spit, as measured from the respective jetties. During this time interval, the only erosion or shoreward movement of the high water shoreline occurred along the reach approximately 3 to 6 miles north of the north jetty. The maximum shoreward movement was 200 feet.

Active erosion is also occurring to the salt marshes along the bay margins and on Indian Island. Thompson (1971) indicates that marsh retreat between North Point and Eureka Slough occurred at an average rate of 2 to 4 feet per year between 1911 and 1966. Wave action is considered to be the primary cause for shoreline erosion along the east side of Arcata Bay, although relative sea level rise is probably also contributing (see Tidal Characteristics, Section VI.G).

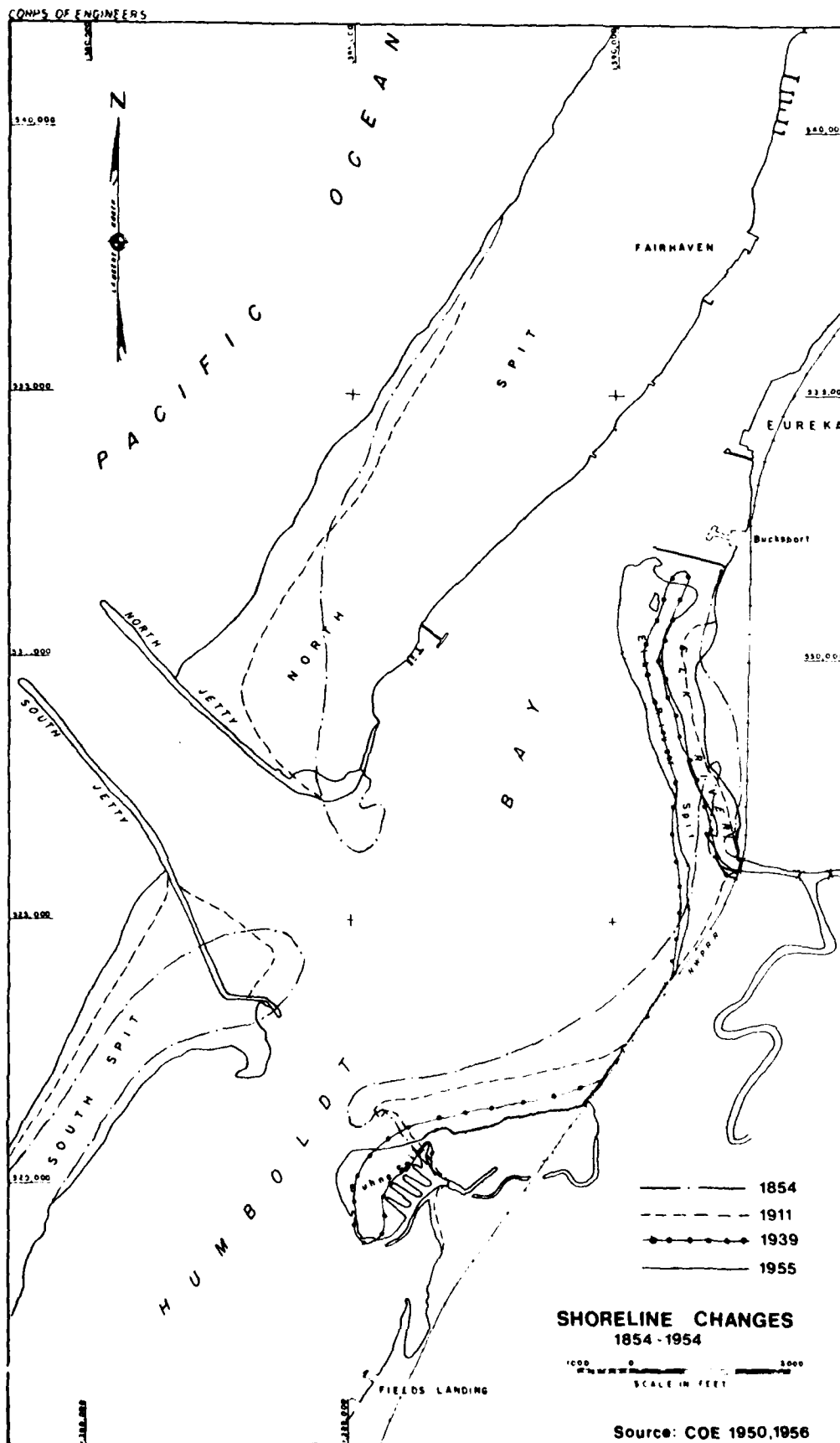


Figure VI-9a

E. MINERAL RESOURCES

The economic mineral commodities of the Humboldt Bay area are natural gas, sand and gravel, and stone (Plate 7). Other resources that have been utilized, but are not of significant economic value, are clay and limestone. Clay has been mined in the Eureka area for the manufacture of bricks and tile, and small deposits of limestone have been quarried for agricultural purposes. There is no production of metallic minerals in western Humboldt County.

Natural Gas

Surface indications of petroleum led to exploratory drilling in the late 1930's for oil and gas. An abundant supply of natural gas was found, but no commercially valuable deposits of oil were discovered in the Eureka area.

Current production of natural gas primarily comes from the Tompkins Hill gas field, which is 12 miles south of Eureka. The Table Bluff field has produced natural gas in the past, but is presently not in production. Exploratory wells have been drilled in the Arcata and Ferndale Bottoms but the expected yield from these locations is not known. No other gas fields are recognized in western Humboldt County; however, additional reserves offshore have been estimated at 71.5 billion cubic feet in the Outer Continental Shelf tract number 53. Production of natural gas from Humboldt County has steadily climbed to an annual yield of 1,849,966,000 cubic feet in 1976 (CDMG, 1978). County statistics do not show dollar value of natural gas and petroleum, since the well-head prices vary from field to field. Humboldt County produced only about .5% of the statewide total for 1976.

Sand and Gravel

The production of sand and gravel is controlled by the demands of the community for construction purposes. Economically, the source should be close to the consumers to reduce transportation cost and be easily obtainable. In Humboldt County the Mad, Eel, and Van Duzen Rivers provide an abundant supply and are close to major population centers. A year's extraction of sand and gravel from these river bars is usually replaced during the following winter's high water stage (CDMG, 1961).

Hookton gravels have been quarried from a few selected locations. These gravels are primarily used for bulk fill where there is no need for size sorting.

Total production figures of sand and gravel for 1976 have been placed at 1,008,946 short tons valued at \$2,346,119 (CDMG, 1978). These values are expected to rise with a growing economy.

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NOT FOR LEGAL USE



MINERAL RESOURCES

PLATE NO 7 NORTH

LEGEND



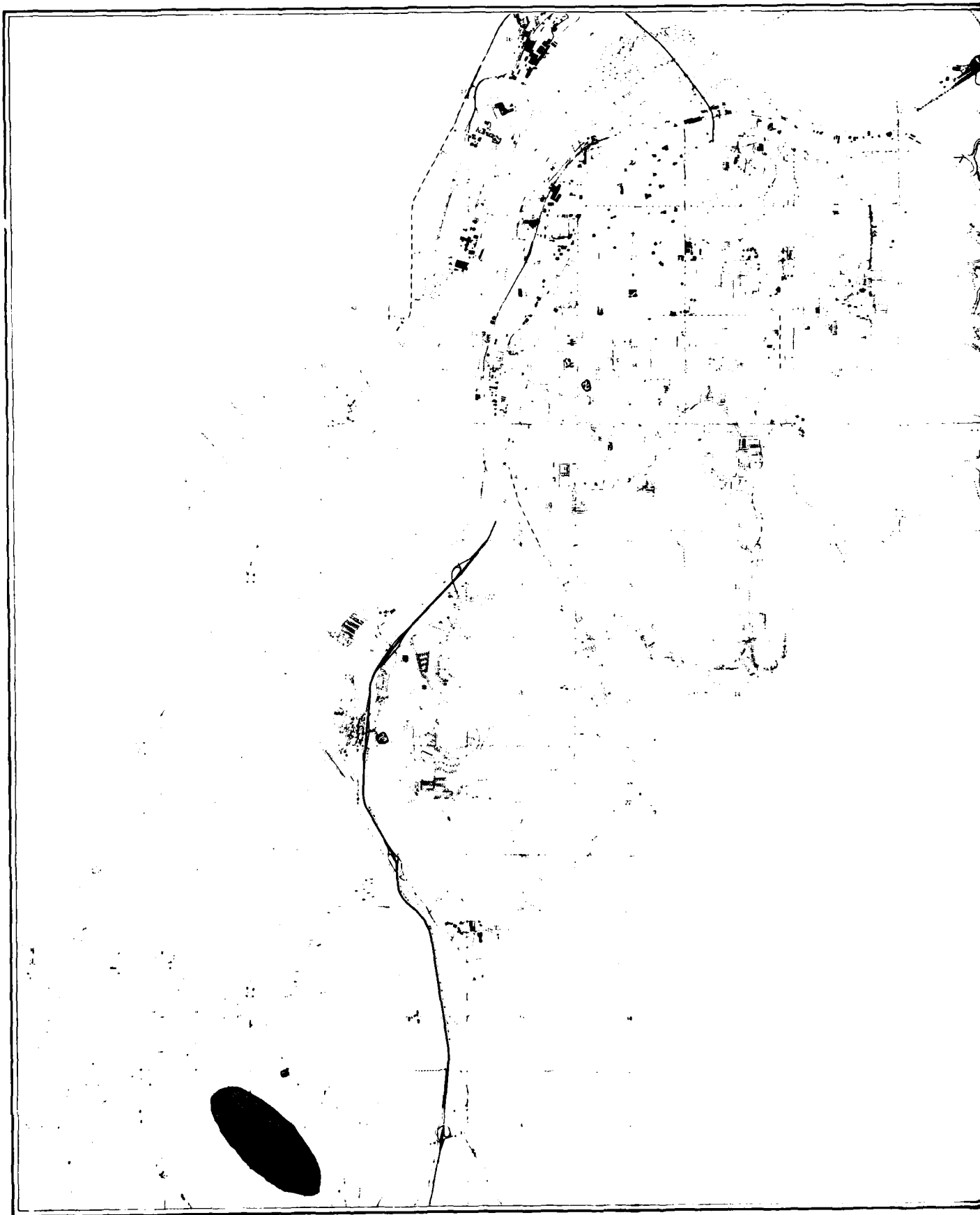
Sand & Gravel



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: California Division of Mines
and Geology 1962





MINERAL RESOURCES

PLATE NO 7 SOUTH

LEGEND



Natural Gas



Quarry



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: California Division of Mines
and Geology 1962

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Stone

Crushed rock has been principally used by logging companies for road metal on secondary roads in the back country. Chert and basalt are largely used, and outcrops are abundant in the Franciscan complex.

Blocks of graywacke sandstone commonly have been used as riprap and crushed rock; however, blueschist, because of its higher specific gravity, greater strength, and low water sorption, has been recognized as an important rock for this purpose. The amount of stone produced in Humboldt County for 1976 was 88,774 short tons, valued at \$138,453 (CDMG, 1978).

F. SOILS

Soils are the result of physical and chemical weathering processes which change the natural geologic parent material. The depth and degree of weathering of the soil are functions of: the composition of the parent material; the topography, including the slope aspect; the climatic conditions during soil forming processes; the plants and animals living on and in the soil; and the amount of time these processes have acted on the parent material.

As a means of identifying different soil types and describing their characteristics, the U.S. Soil Conservation Service (SCS) has developed a classification system based primarily on the parent material, texture, and slope of the soil. Although initially developed to assess the agricultural capability and erodability of the soil, the system has been expanded to describe other soil attributes, such as resource value, urban development limitations, and woodland suitability. More recently, classification systems have been established to identify prime agricultural soils.

A generalized soil association map (Figure VI-10) and a soil series map (Plate 8) are included in the following sections for general planning purposes and for a detailed description of the soil series that have formed in the Humboldt Bay area. These maps and the following descriptions are based primarily on the Soil Conservation Service Report and General Soil Map, Humboldt County, California, 1967, and on McLaughlin and Harradine, Soils of Western Humboldt County, California, 1965.

Generalized Soil Map

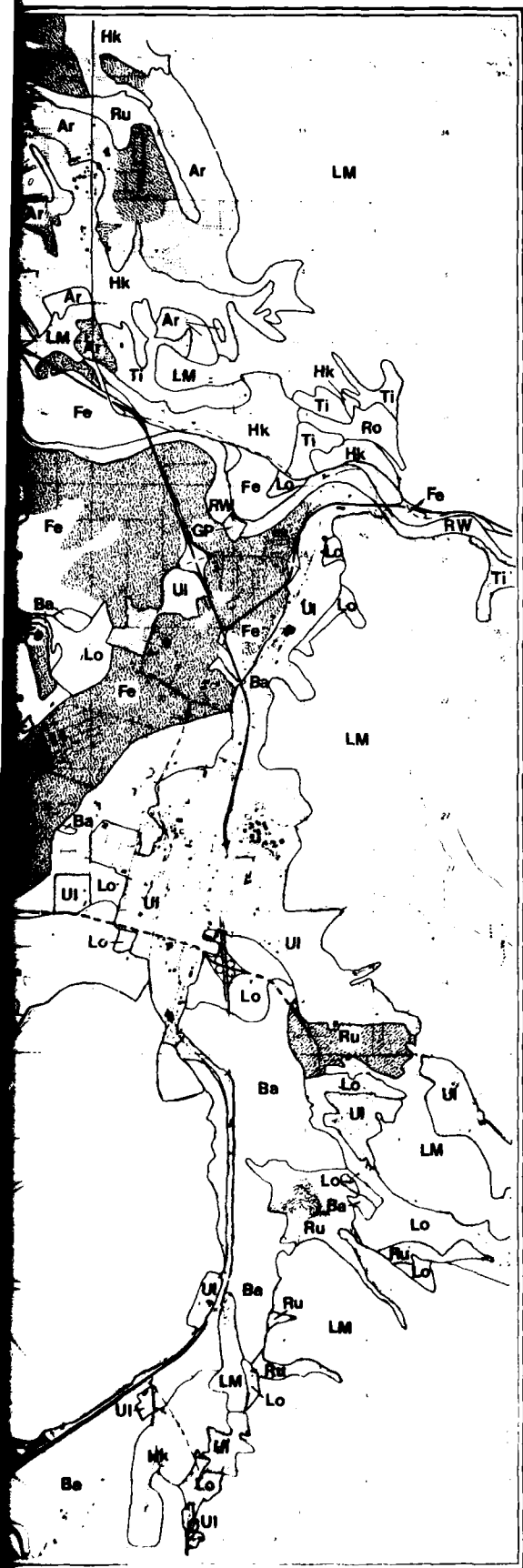
The generalized soil association map of the Humboldt Bay area is shown in Figure VI-10. A soil association is a group of soil types consisting of one or more major soils and at least one minor soil that have formed on a particular landform distinctive of the geographic area. Generalized soils maps are useful for comparison of large areas of land to determine the usefulness and suitability for certain kinds of land use. A brief description of the soil associations and the landforms on which they developed are described below.

The Bayside-Loleta association (BL) occurs adjacent to the bay margins and sloughs where tidal influence was prominent before dikes were built. These are moderately-well to poorly drained, fine to medium textured soils. This association is used primarily for pasture and other forage crops.

The Ferndale-Russ association (FR) soils are formed on nearly level to moderately sloping floodplains and alluvial fan deposits of rivers and streams. These recent stream deposits consist of gra-

ONLY

Geological map of the Keweenaw Peninsula, Minnesota. The map displays various geological units labeled with abbreviations: Hk (Humboldt), Ar (Auriferous), Ru (Roubidoux), Fe (Iron), Ba (Bancroft), Lo (Loup), UI (Unconsolidated), LM (Loup River), SD (Soudan), TM (Tombigwa), and DW (Dewey). The map shows the complex geological structure of the peninsula, including the Keweenaw Peninsula and the surrounding areas. The units are color-coded and labeled throughout the map area.



SOILS

PLATE NO 8 NORTH

LEGEND

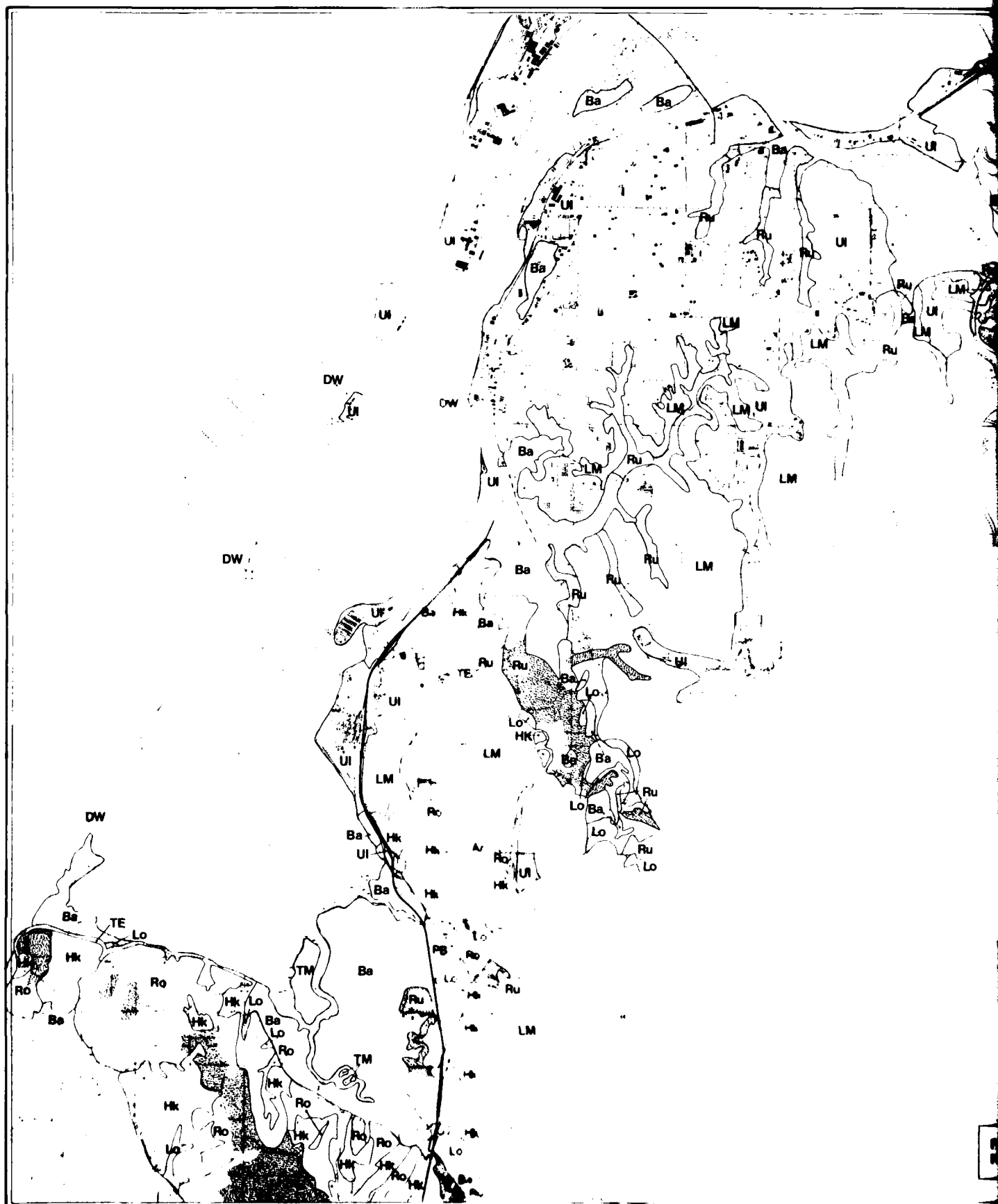
Ar	Arcata
Ba	Bayside
DW	Beach & Dune Land
Fe	Ferndale
GP	Gravel Pit
Hk	Hookton
LM	Larabee-Mendocino Assoc.
Lo	Loleta
PB	Peat Bog
Ro	Rohnerville
Ru	Russ
RW	River Wash
SD	Sand Dune
TE	Terrace Escarpment
TM	Tidal Marsh
Ti	Timmons
UI	Urban/Industrial
	Prime Agricultural Soil



Store Index 80 100

HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: McLaughlin and Harradine 1985





SOILS

PLATE NO 8 SOUTH

LEGEND

- Ar Arcata
- Ba Bayside
- DW Beach & Dune Land
- Fe Ferndale
- GP Gravel Pit
- Hk Hookton
- LM Larabee-Mendocino Assoc.
- Lo Loleta
- PB Peat Bog
- Ro Rohnerville
- Ru Russ
- RW River Wash
- SD Sand Dune
- TE Terrace Escarpment
- TM Tidal Marsh
- Ti Timmons
- UI Urban/Industrial
- Prime Agricultural Soil



Storie Index 80-100

HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: McLaughlin & Harradine 1965

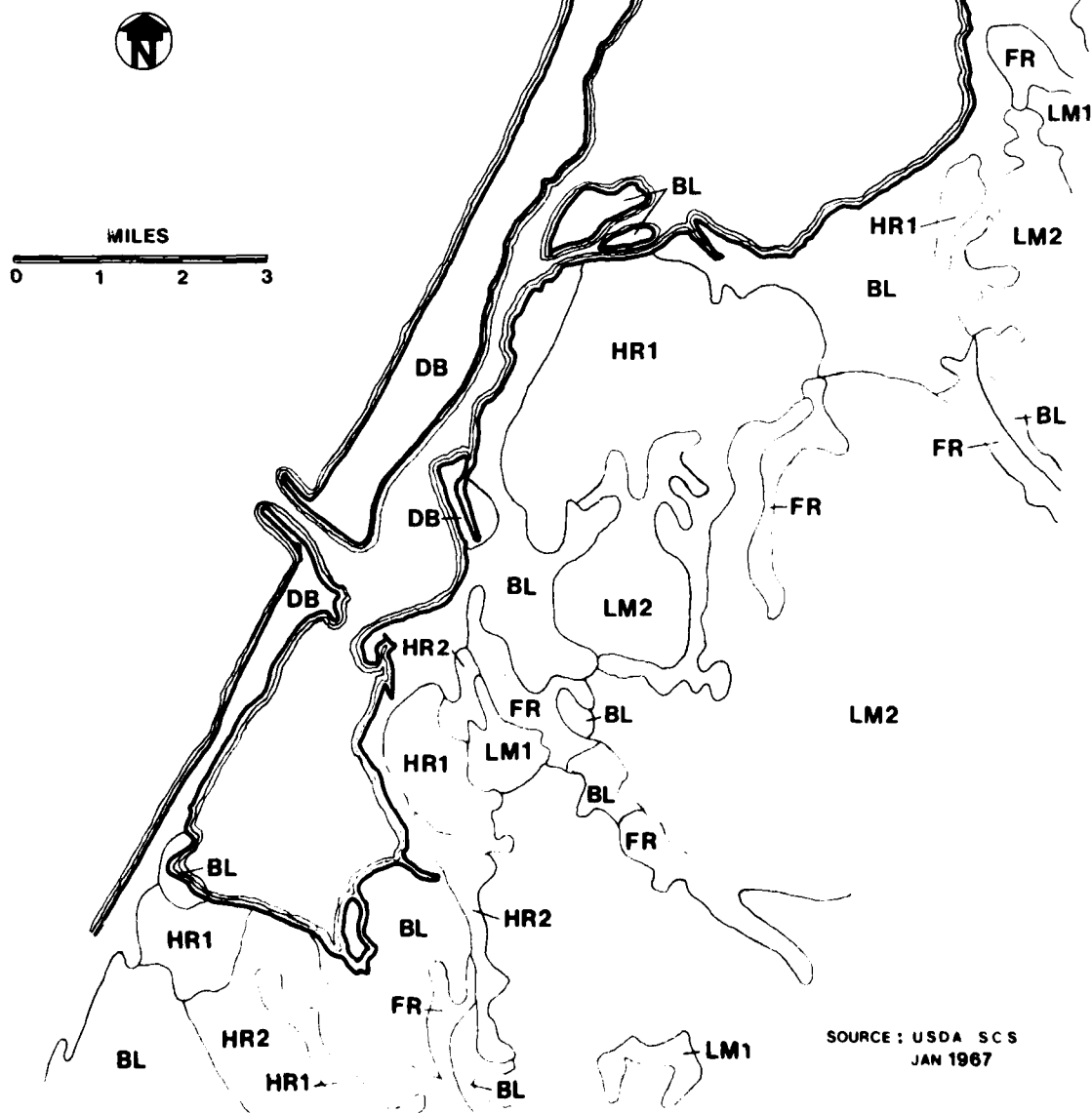
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Figure VI-10

GENERAL SOILS MAP

HUMBOLDT COUNTY

ASSOCIATION		SLOPE
BL	BAYSIDE-LOLETA	0-9%
FR	FERNDALE-RUSS	0-9%
HR1	HOOKTON-ROHNERVILLE	0-15%
HR2	HOOKTON ROHNERVILLE	3-50% ERODED
LM1	LARABEE-MENDOCINO	0-30%
LM2	LARABEE-MENDOCINO	30-50%
DB	DUNE LAND-BEACH	



SOURCE: USDA SCS
JAN 1967

vel, sand, and silt and are, therefore, well to moderately-well drained with moderate permeability. These soils are used for field and forage crops.

The Carlotta-Ettersburg association (CE) occurs on nearly level to gently sloping low river terraces. These soils are moderately-well to well drained depending on the coarse sediment content of the parent material. Conifers are the natural vegetation, and the soil is used for pasture.

The Hookton-Rohnerville association (HR1, 0 to 15 percent slopes; HR2, 3 to 50 percent slopes, eroded) is developed on the marine sedimentary deposits of McKinleyville, Arcata, and Eureka terraces and on Humboldt Hill and Table Bluff. Erosion hazard is moderate to high. From 6 to 30 inches of the HR2 soil has been lost or moved downslope from erosion. These soils are well to moderately well drained, and permeability is moderate. The soil is used for forage crops and urban development.

The Larabee-Mendocino association (LM1, 0 to 30 percent slopes; LM2, 30 to 50 percent slopes) forms on the uplands underlain by soft sedimentary rocks of the Wildcat Group, southeast of Eureka. Erosion hazard is dependent on slope, and varies from slight on the level surfaces to high on the steep slopes. The soils are moderately well drained, and permeability is moderate to moderately slow. The native vegetation is redwood and Douglas fir forest.

Soil Series Mapping Units

The following soil descriptions and mapping units (Plate 3) of the Humboldt Bay area have been obtained from McLaughlin and Haradine (1965). These soil series describe the specific landform and substratum on which the soils developed and the vegetation that is best suited for agricultural purposes.

Arcata Soils (Ar): The Arcata series is developed on the elevated marine and sand dune deposits of the McKinleyville terrace, on flat to gently westward dipping slopes. The soils vary in texture from loam to fine sandy loam, are dark brown, and are well drained. Native vegetation consists chiefly of spruce and alder, and native grasses and bracken fern occur in the small open areas. Flower bulbs and permanent pasture are the dominant crops grown on the Arcata soils. These soils are associated with the Hookton and Hely series.

Bayside Soils (Ba): The Bayside series occurs within 10 miles of the bay margin in tidal marsh areas and in small stream basins where drainage is poor. Much of the tidal marsh areas have been diked and drained. The soils are developed on alluvium that ranges in elevation from sea level to below 50 feet. The Bayside series consists of fine textured, silty clay loams that are imperfectly to poorly drained. Native vegetation in the stream basins con-

sists of willow, spruce, and rush, and in the tidal marsh areas, silverweed, pickleweed, and rush occur. These areas are used for the production of nonirrigated forage. Introduced species include birds-foot trefoil, salina clover, meadow foxtail, alta fescue, and in the poorly drained areas, reed canarygrass. These soils are associated with the Ferndale, Russ, and Loleta soils.

Ferndale Soils (Fe): The Ferndale series occurs on the flat lying Arcata Bottoms of the Mad River floodplain. The Ferndale soils consist of a range of fine sandy loam to a silty clay loam. Drainage is generally good. Areas adjacent to the Mad River were covered with sand and silt deposits, generally less than one foot thick, from the 1964 flood. Ferndale soils are prime agriculture land, with excellent yield of high quality feed. Mixtures of ladino clover and rye grass, or salina clover, and orchard grass are prominent. These soils are associated with the Bayside, Loleta, and Russ series.

Hookton Soils (Hk): The Hookton soils occur on the elevated, semi-consolidated sediments of the Hookton Formation on parts of the McKinleyville Terrace, Humboldt Hill, and Table Bluff. The amount of soil development is dependent on slope, which varies from flat lying surfaces to deeply dissected and eroded steep slopes. The Hookton series consists of moderately deep prairie regosols with texture ranging from silty clay loam to silt loam. The soil is generally well drained, but is dependent on the density of the substratum. Most of the soils have produced hay crops, but have been converted to annual clovers and grasses due to poor productivity. The Hookton series is genetically associated with the Rohnerville and Loleta series.

Loleta Soils (Lo): The Loleta series occurs on nearly level to moderately sloping alluvial fans and low terraces. These soils consist of loam to clay loam, and are well to imperfectly drained, with some poor drainage sites occurring on nearly every fan. Because of restricted drainage, water-tolerant plants for pasture crop are most productive. The Loleta soils are genetically related to the Russ, Bayside, and Rohnerville series.

Rohnerville Soils (Ro): The Rohnerville series occurs on the high terraces of the Hookton Formation on Table Bluff. Slopes are low to moderately steep. These soils are characteristically well drained, with a good moisture-holding capacity, and typically have a black surface horizon with a silty clay loam texture. Rohnerville soils are capable of producing excellent yields of pasture and hay crops. The Rohnerville series is related to the Hookton and Loleta series, and are associated with upland or residual soils of the Larabee and Empire series.

Russ Soils (Ru): The Russ series is developed in alluvial deposits along small streams draining the Wildcat sediments. These

soils consist of well to moderately-well drained, dark grayish brown silty clay loam to fine sandy loam surfaces. Native vegetation consists of willow, alder, and brush species. The soils are used for pasture, and water-tolerant plants grow well in imperfectly drained soils. The Russ soils are genetically related to the Joleta and Bay-side series and are associated with the Ferndale series.

Timmons Soils (Ti): The Timmons series occurs on smooth, flat, slightly dissected high terraces of the Hookton Formation. These soils are characteristically well drained and have brown clay loam surface horizons. Coniferous forests are the predominant growth, and these soils are devoted to timber production. Timmons soils are associated with upland residual soils of the Mendocino and Hely series.

Other Soils: The upland areas, generally above 300 feet elevation, consist of deeply weathered residual soils occurring on steep to moderately steep slopes. These include the Larabee, Empire, Hely, and Mendocino series. Redwood and Douglas fir forests are the native vegetation.

Miscellaneous Land Use Types

Miscellaneous land types consist of eight mapping units based on present land use, and are briefly described as follows:

- . Gravel Pit (GP): areas along the Mad River where gravel extraction is used for commercial purposes.
- . Modified Land (MA): areas that have been leveled and filled with imported materials for construction or other purposes.
- . Peat Bog (PB): small, poorly drained, low lying areas that have greater organic accumulation than mineral matter.
- . River Wash (RW): areas of recent deposits of silt, sand, and gravel adjacent to river banks, which are subject to flooding and typically have willow and cottonwood as the dominant vegetation.
- . Sand Dunes (SD): areas adjacent to the ocean and beach consisting predominately of loose wind-blown sand deposits that are maintained by either lupine and grass or a pine and huckleberry vegetative association.
- . Terrace Escarpment (TE): areas consisting of slopes greater than 70% between the high terraces and alluvial bottoms.
- . Tidal Marsh (TM): areas that are subject to tidal influence and support hydrophytic species.
- . Urban and Industrial (UI): areas that had agricultural potential but are covered by houses or industrial buildings.

Prime Agricultural Soils

Considerations should be given to the preservation of agricultural land, and decisions should be avoided that commit prime land to nonagricultural uses. Continued loss of agricultural land to irreversible land use developments represents a loss of a valuable natural resource and the production of food, feed, and forage crops. Other reasons cited for protection of these lands include open space, environmental quality, visual quality, and local economic impacts.

The protection of prime agricultural lands is a very high priority in Coastal Act policies. Prime agricultural land, as defined by the Soils Conservation Service (SCS, Memo WA-1, 1967), is farmland best suited and available for producing food, feed, forage, fiber, and oilseed crops. Prime lands have the "...soil quality, growing season, and moisture supply needed to produce sustained high yields of crops economically when treated and managed, according to modern farming methods." These requirements identify two factors for prime agricultural land designation: the actual land value based on physical characteristics of the soil, and the economic value determined by yield and management practices.

The definition of prime agricultural land was provided by the Williamson Act and has been adopted by the Coastal Act for planning purposes. The Williamson Act, or the California Land Conservation Act, was established in 1960 for the preservation of open space and protection of agricultural land from urban development by providing tax reductions to farm operators. Prime agricultural land is defined as follows and is section 51201(c) of the California Government Code:

- (1) *All land which qualifies for rating as Class I or Class II in the Soil Conservation Service land use capability classifications.*
- (2) *Land which qualifies for rating 80 through 100 in the Storie Index Rating.*
- (3) *Land which supports livestock used for the production of food and fiber and which has an annual carrying capacity equivalent to at least one animal unit per acre as defined by the U.S.D.A.*
- (4) *Land planted with fruit or nut-bearing trees, vines, bushes or crops which have a non-bearing period of less than five years and which will normally return during the commercial bearing period on an annual basis from the production of unprocessed agricultural plant production not less than \$200 per acre.*
- (5) *Land which has returned from the production of unprocessed agricultural plant products on an annual gross value of not less than \$200 per acre for three of the five previous years.*

Land that is returned from the production of agricultural plant products on an annual gross value of \$100 per acre for three of the five preceding years.

Definitions, two types of prime agricultural lands have been designated by the Humboldt County Local Coastal Program (LCP). These lands are designated according to their inherent capability to produce yields of food crops, as defined by Soil Conservation Service Capability Class I or Class II or Storrie Index B or C, as described below. Prime II lands, on the other hand, are designated according to their current economic yield, which is based on current management practices and market values.

The Soil Conservation Service Capability Classification groups individual soils into groups based on their ability to produce common cultivated crops without soil deterioration over a long period of time. The classification is based on the risks of soil damage and the degree of soil factors, limitations in use, and production. A high level of management is assumed. Considerable areas where improvements have been made, such as irrigation. Classification is subject to change if major projects are installed or new information about the soil is available.

There are eight different capability classes that range from the increasing degree of hazards or limitations for land use. Classes I-IV are suitable for cultivation and other uses, whereas Classes V-VIII are not generally suited for agriculture. Class I soils have few limitations that restrict their use, and Class II soils have some limitations that reduce the choice of plants or require moderate conservation practices. Both Class I and Class II soils are considered prime agricultural soils according to the Williamson Act definition. In the Humboldt Bay area, only the Carlotta-Ettersburg and Ferndale-Russ soil associations have Class II capability classification (Figure VI-10).

The Storrie Index rates soils based upon soil characteristics rather than economic aspects, and expresses numerically the suitability of a soil for general intensive agriculture. There are four general factors that are considered when rating soils: character of the soil profile and development; texture of the surface soil; slope; and other factors such as drainage, alkali and nutrient levels, erosion, and microrelief. Each factor is rated on a scale of 100 percent. The four groups are then multiplied, and placed in a soil grade based on the product of the four groups. There are six grades, each referring to the degree of physical suitability.

Grade 1 soils are excellent soils and are well suited for general intensive agriculture. The soils are easily worked, require no special erosion control measures, and are highly productive. Such soils have Storrie Index ratings of 80-100 and are, therefore, classed as prime agriculture land based on the above definition.

Storie Index ratings have been determined for the soils of Western Humboldt County (McLaughlin and Harradine, 1965) and the prime agricultural soils are indicated in Plate 8, Soils, by the shading pattern. These include: Arcata, Ferndale, Rohnerville, and Russ soils. The prime agricultural soils do not always conform to the mapped soil boundaries because of the variation of mapping detail. These variations of the soil series are a reflection of soil composition, slope, drainage condition, and degree of erosion of the soil. In fact, the Ferndale soils that are largely considered to be prime agricultural soils may have poor drainage conditions, and hydrophytic weeds are quite difficult to control. These soils, as well as some Loleta soils and the Bayside series, are hydric soils. Drainage is a limiting factor that limits crop selection unless artificial drainage is provided.

G. TIDAL CHARACTERISTICS

The tides in Humboldt Bay are characterized by a diurnal inequality; that is, successive high or low tides have different elevations. This inequality is illustrated in Figure VI-11. On extreme tides this inequality may amount to as much as a 4 foot difference in successive lows (12 June 1979) or a 2.6 foot difference in successive highs (25, 26 January 1979).

Eleven tide stations have been established in Humboldt Bay since 1919. Locations of these stations are shown on Figure VI-12; the period of tidal record for each station is noted in Table VI-3. Distances between stations were measured along channels, and not in a straight line.

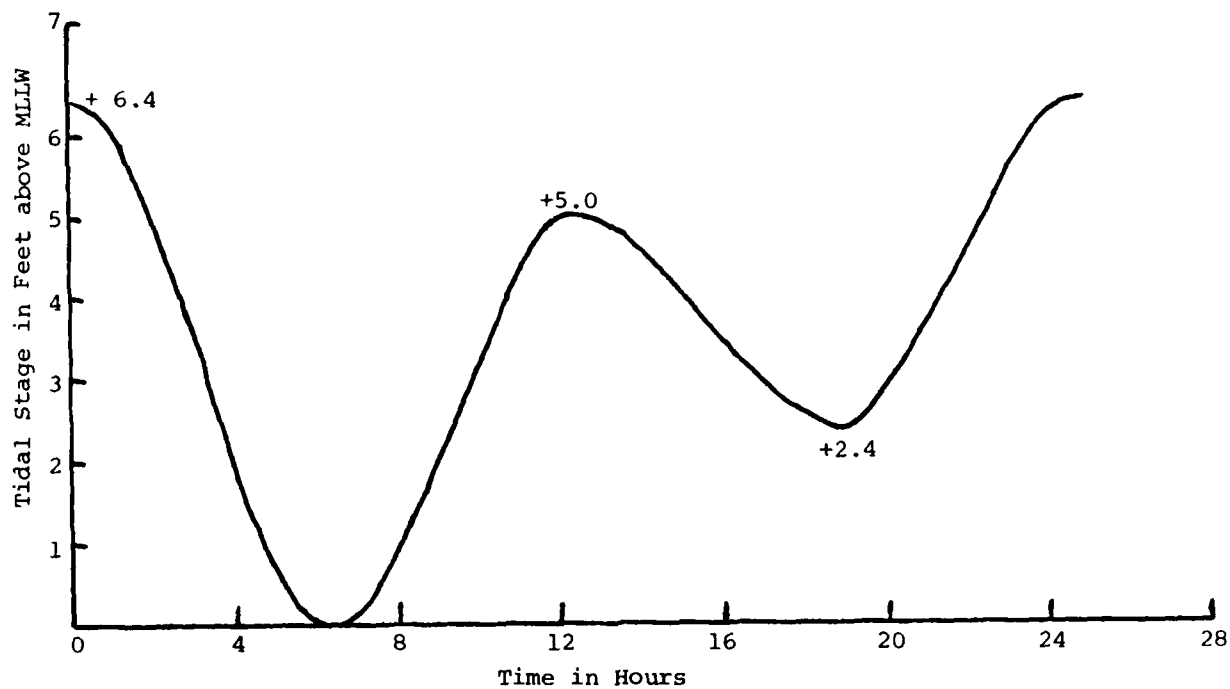
From the data in Figure VI-13, several tidal characteristics of Humboldt Bay can be inferred. First, diurnal tide range (MHHW-MLLW) seems to increase with distance from the North Spit gauge in North Bay but not in South Bay. This is not true, however, for up-river stations such as Elk River and Freshwater Slough where river discharges undoubtedly damp tidal fluctuations. As would be expected, mean tide level exhibits a similar, though smaller, increase with distance from the North Spit gauge.

In Figure VI-14 tidal datums are shown with respect to NGVD*. MHHW and MTL differ by less than 0.25 feet for all stations (except Elk River). MLLW, however, exhibits a difference of more than 0.6 feet between North Spit and Mad River Slough, and a distinct drop with respect to NGVD with increasing distance northward from North Spit.

Tide tables (NOAA, 1978) also indicate a variation in the time of high and low waters. These data are presented in Table VI-4, and are displayed as cotidal lines in Figure VI-15. It is apparent that the tide moves more quickly into South Bay than into North Bay. It also appears that low tide at any station within the Bay does not "lag" as much as high tide. Of particular interest are the differences at Samoa and Eureka. Although high tide is slightly later at Samoa than at Eureka, low tide is significantly earlier. The cause of this lag is unknown, but it may represent a slower ebb from Eureka Slough.

In addition to geographic variations, tidal datums also exhibit some historic variation. Figure VI-16 shows these changes for Eureka, North Spit, Fields Landing, and Samoa. Of interest is the fact that only North Spit has shown no fluctuation of either mean

*NGVD - National Geodetic Vertical Datum, formerly called Sea Level Datum of 1929. A geodetic datum identified as 0 elevation on topographic maps. This datum should not be confused with mean sea level or any other tidal datum.



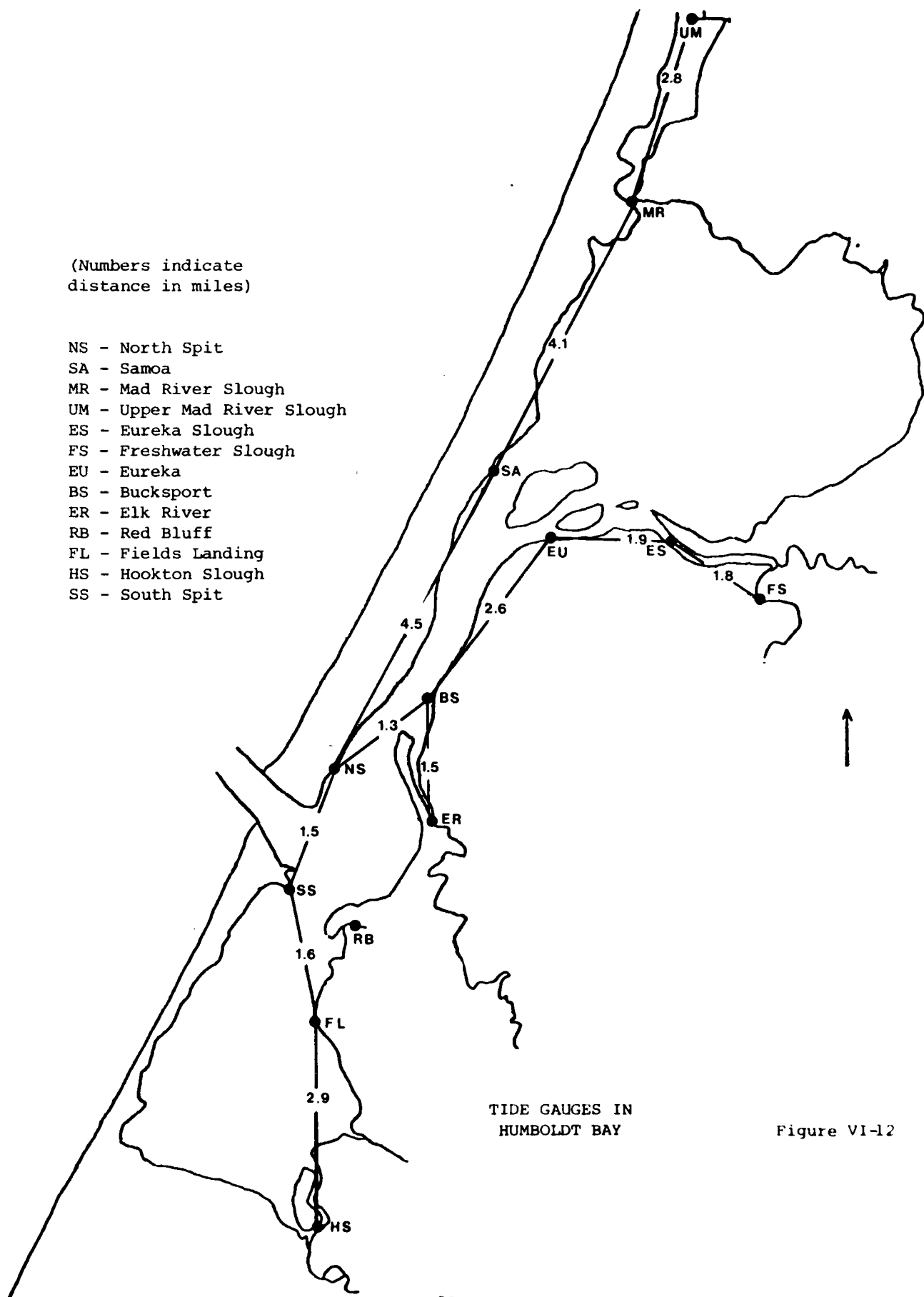
Source: Corps, 1976

MEAN TIDE CURVE, SOUTH JETTY
HUMBOLDT BAY

Figure VI-11

(Numbers indicate
distance in miles)

NS - North Spit
SA - Samoa
MR - Mad River Slough
UM - Upper Mad River Slough
ES - Eureka Slough
FS - Freshwater Slough
EU - Eureka
BS - Bucksport
ER - Elk River
RB - Red Bluff
FL - Fields Landing
HS - Hookton Slough
SS - South Spit



TIDE GAUGES IN
HUMBOLDT BAY

Figure VI-12

Table VI-3

TIDAL STATISTICS IN HUMFOLDT BAY
(0.0 equals MLLW)

Station	Dates Occupied	Extreme High Water ¹	MHHW	MHW	MTL	MLW	Extreme Low Water ¹	NGVD-MLLW	Mean Range (MHW-MLW)	Diurnal Range (MHHW-MLLW)
North Spit	10/40-3/41	9.5	6.70	6.00	3.60	1.20	-3.0	NA ²	4.80	6.70
	8/16/77-Present ⁴	NA	6.70	6.00	3.60	1.20	NA	3.65	4.80	6.70
Samoa	9/62-10/62	10.0	7.00	6.30	3.75	1.20	-3.0	NA	5.10	7.00
	4/3/78-Present ⁴	NA	7.20	6.50	3.85	1.20	NA	3.93	5.30	7.20
Mad River Slough	9/14/77-Present ⁴	NA	7.50	6.80	4.10	1.30	NA	4.28	5.50	7.50
Upper Mad River Slough	7/21/78-1/79	NA	7.80	7.10	4.15	1.30	NA	NA	5.80	7.80
Eureka Slough	3/31/78-Present ⁴	NA	7.30	6.60	3.95	1.20	NA	3.99	5.40	7.30
Freshwater Slough	3/30/78-1/79	NA	7.00	6.30	3.70	1.00	NA	NA	5.30	7.00
Eureka	9/19/19-10/28/19	10.0	6.70	6.00	3.60	1.20	-3.0	3.34	4.80	6.70
	8/17/77-Present ⁴	NA	7.10	6.40	3.85	1.20	NA	3.99	5.20	7.10
Bucksport	8/18/77-Present ⁴	NA	6.80	6.10	3.65	1.20	NA	3.74	4.90	6.80
Elk River	9/15/77	NA	5.00	4.30	2.35	0.40	NA	1.96	3.90	5.00
Red Bluff	4/2/78-1/79	NA	6.70	6.00	3.60	1.20	NA	3.65	4.80	6.70
Fields Landing	7/62-9/62	9.5	6.70	6.00	3.55	1.10	-3.0	NA	4.90	6.70
	4/1/78-Present ⁴	NA	6.70	6.00	3.60	1.20	NA	3.65	4.80	6.70
Hookton Slough	9/17/77-Present ⁴	NA	6.80	6.10	3.65	1.20	NA	3.72	4.90	6.80
South Spit	11/11-5/13	9.5	6.40	5.70	3.45	1.20	-3.0	NA	4.50	6.40
Crescent City	1953-71	10.1 ³	6.90	6.30	3.75	1.20	-2.8 ³	3.72	5.10	6.90
San Francisco (Golden Gate)	NA	NA	5.70	5.10	3.10	1.10	NA	2.86	4.00	5.70

¹ Estimated, except where noted³ Observed⁴ Preliminary Datums (NOAA, 1979)² Not Available

MHHW - Mean Higher High Water

MHW - Mean High Water

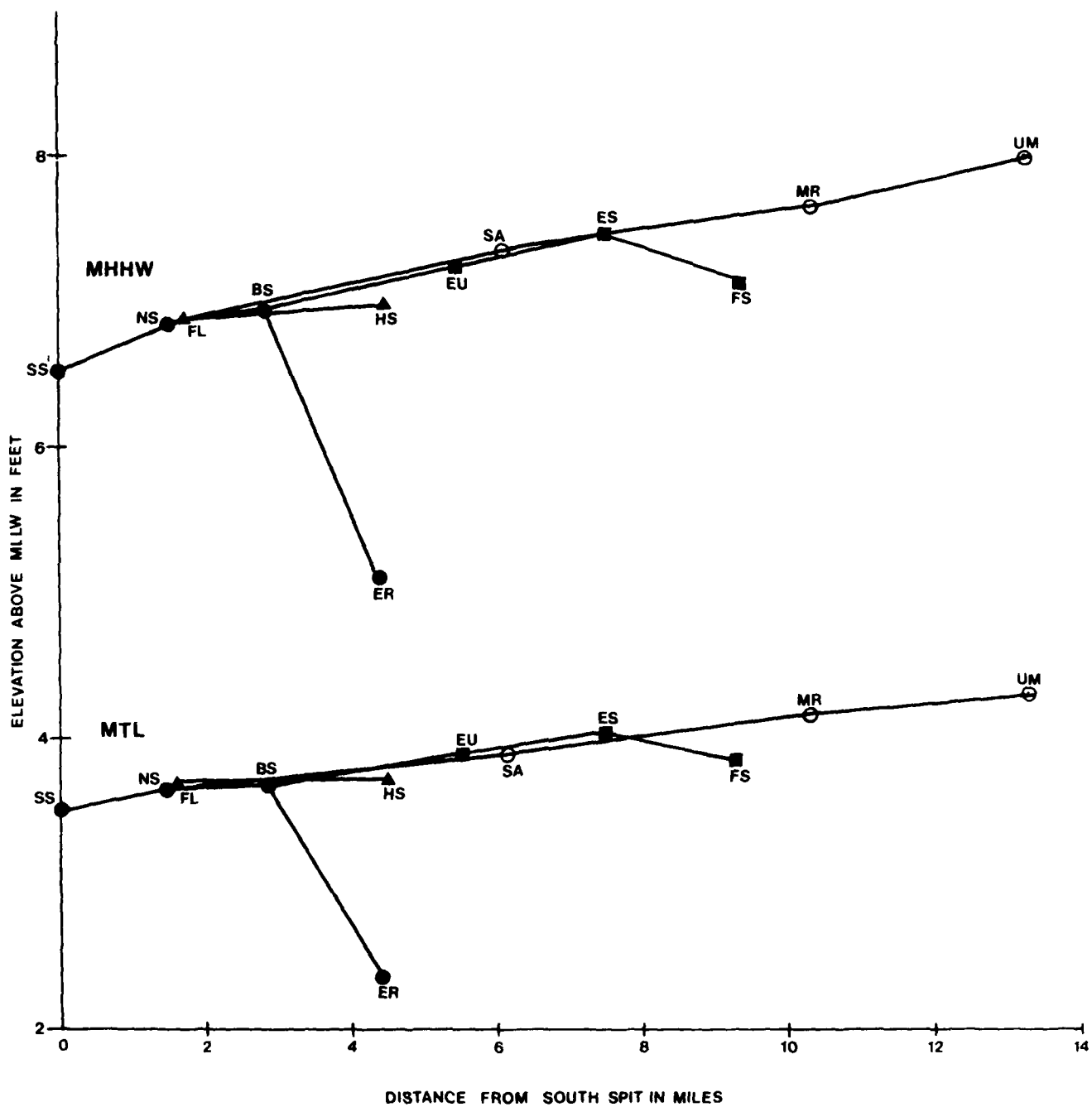
MTL - Mean Tide Level

MLW - Mean Low Water

MLLW - Mean Lower Low Water

NGVD - National Geodetic Vertical Datum

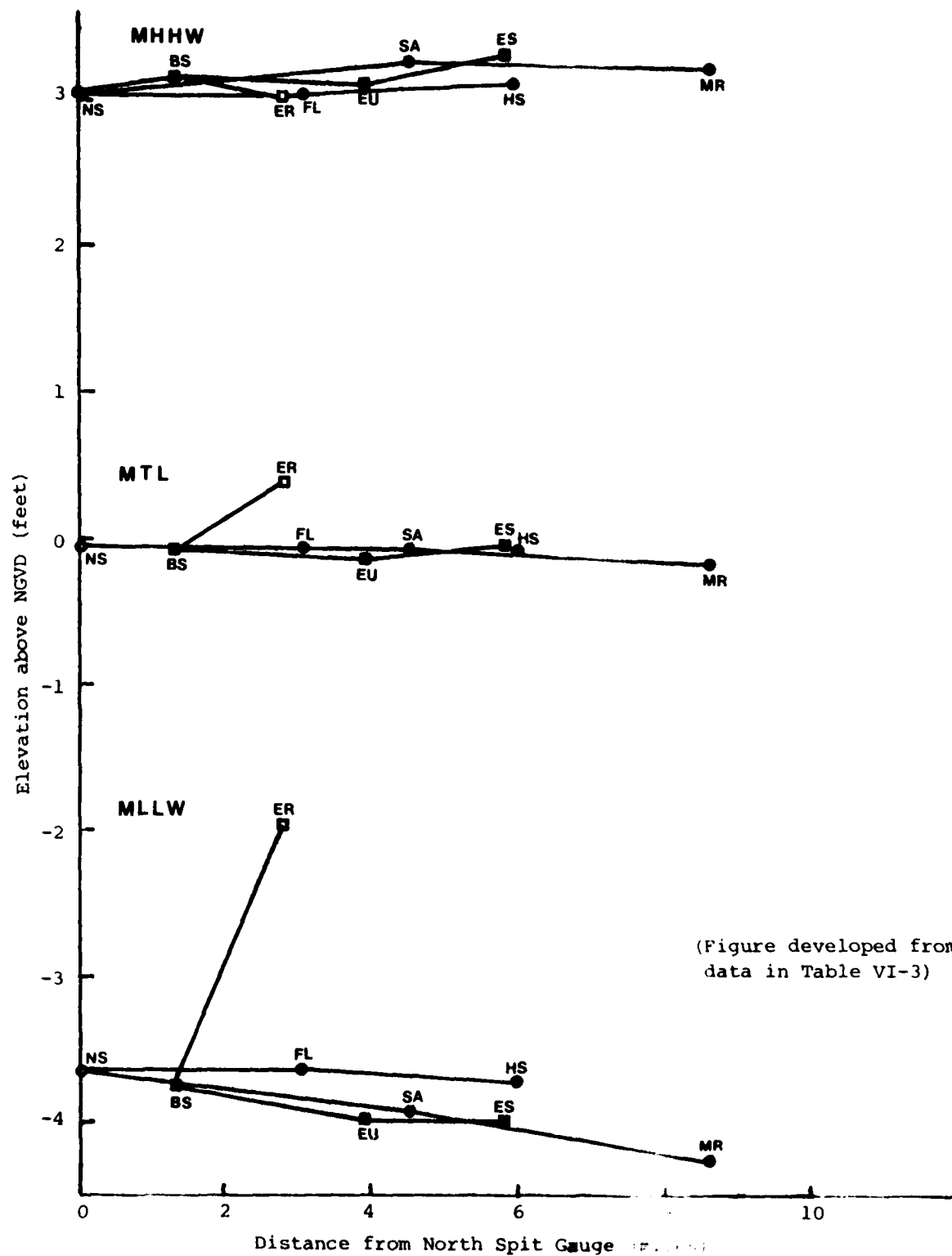
Source: J.R. Hubbard, NOAA Tides Branch



(refer to Figure VI-12 for abbreviations)
 (Figure developed from data in Table VI-3)

TIDAL DATUMS IN HUMBOLDT BAY

Figure VI-13



(Figure developed from data in Table VI-3)

TIDAL DATUMS IN HUMBOLDT BAY WITH RESPECT TO NGVD
(Refer to Figure VI-12 for abbreviations)

Figure VI-14

Table VI-4

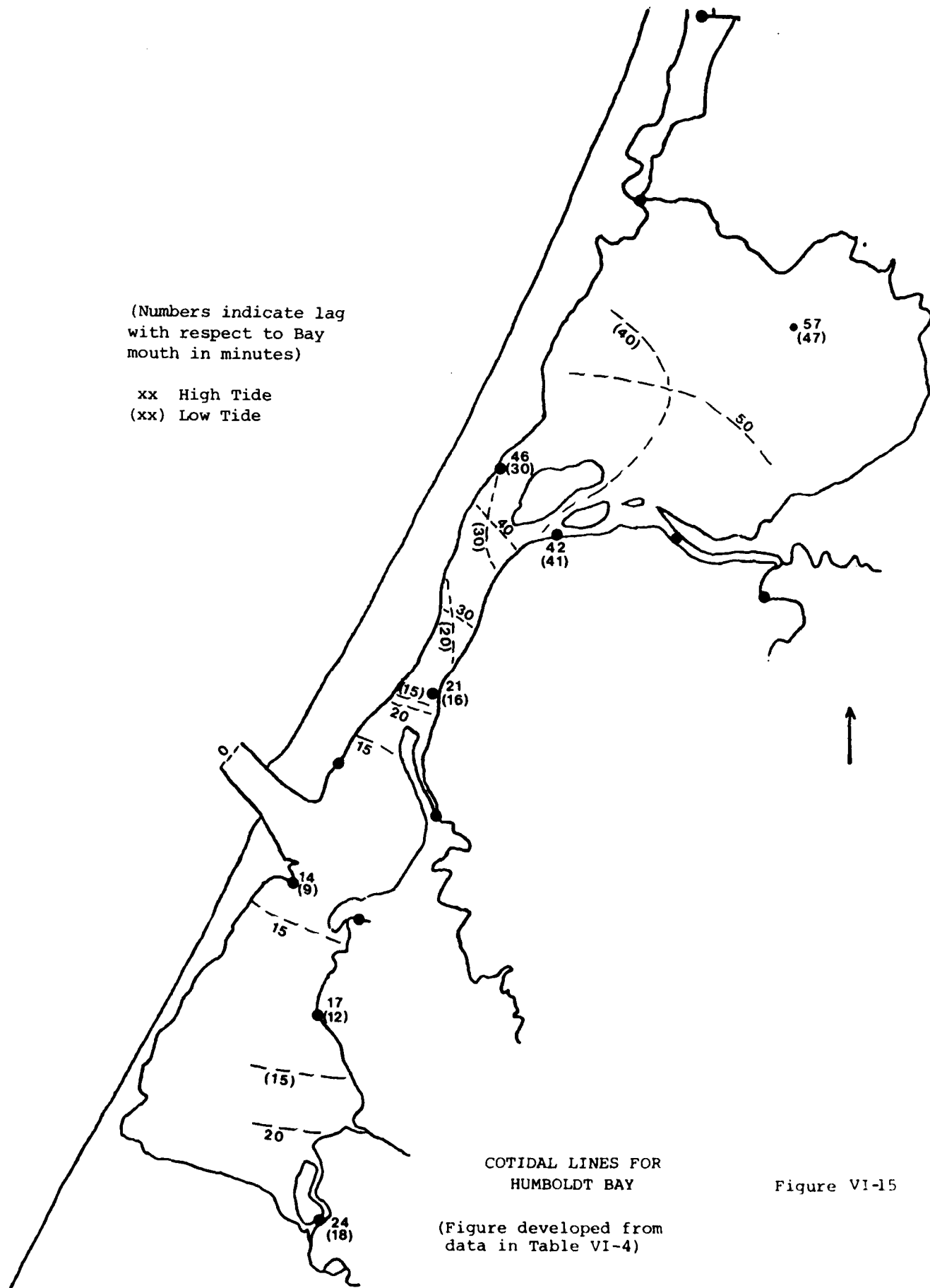
PREDICTED DIFFERENCES IN TIME
OF HIGH AND LOW TIDE
IN HUMBOLDT BAY

<u>Station</u>	<u>High</u>	<u>Low</u>
	<u>Water</u>	<u>Water</u>
	<u>h. m.</u>	<u>h. m.</u>
South Jetty	0 0	0 0
Entrance	-0 14	-0 09
Fields Landing	+0 03	+0 03
Hookton Slough	+0 10	+0 09
Bucksport	+0 07	+0 07
Eureka	+0 28	+0 32
Samoa	+0 32	+0 21
Arcata Wharf	+0 43	+0 38

Source: NOAA, 1979

(Numbers indicate lag
with respect to Bay
mouth in minutes)

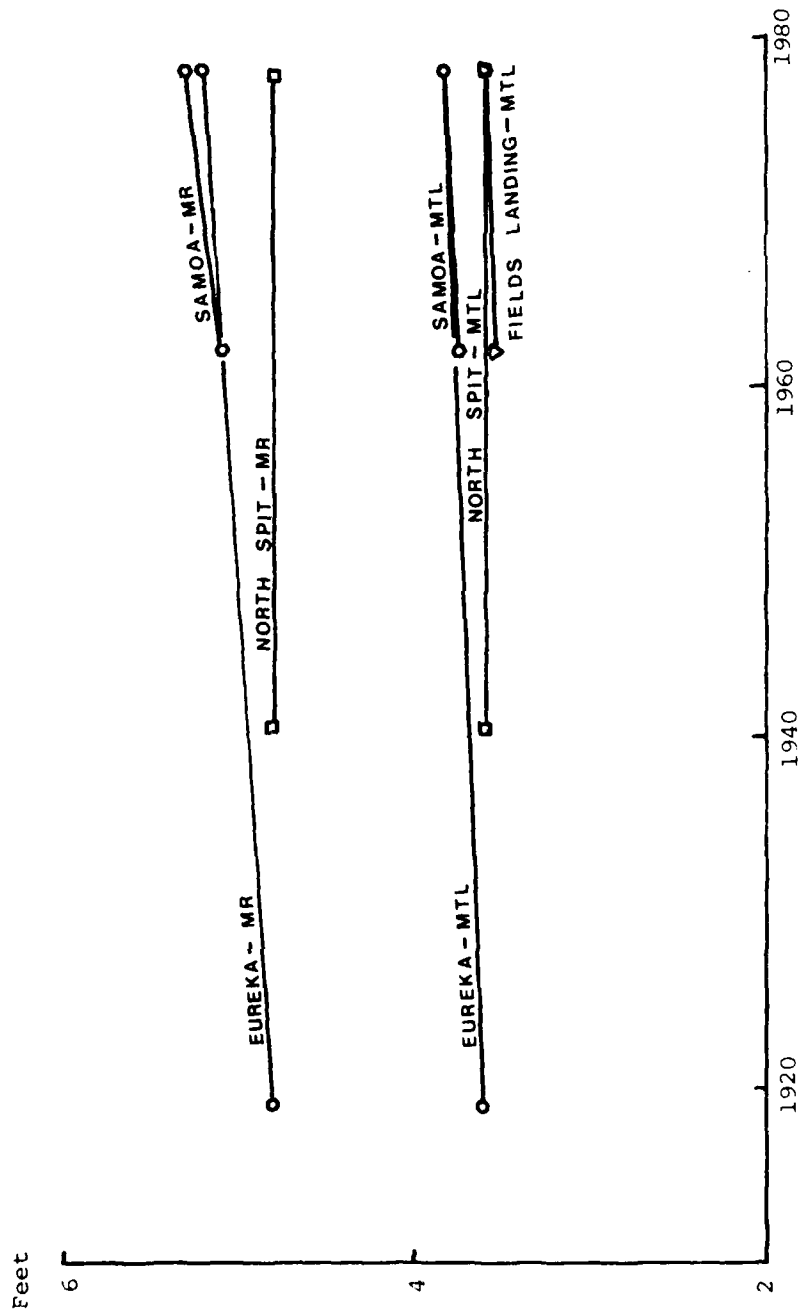
xx High Tide
(xx) Low Tide



COTIDAL LINES FOR
HUMBOLDT BAY

Figure VI-15

(Figure developed from
data in Table VI-4)



MR - Mean Range

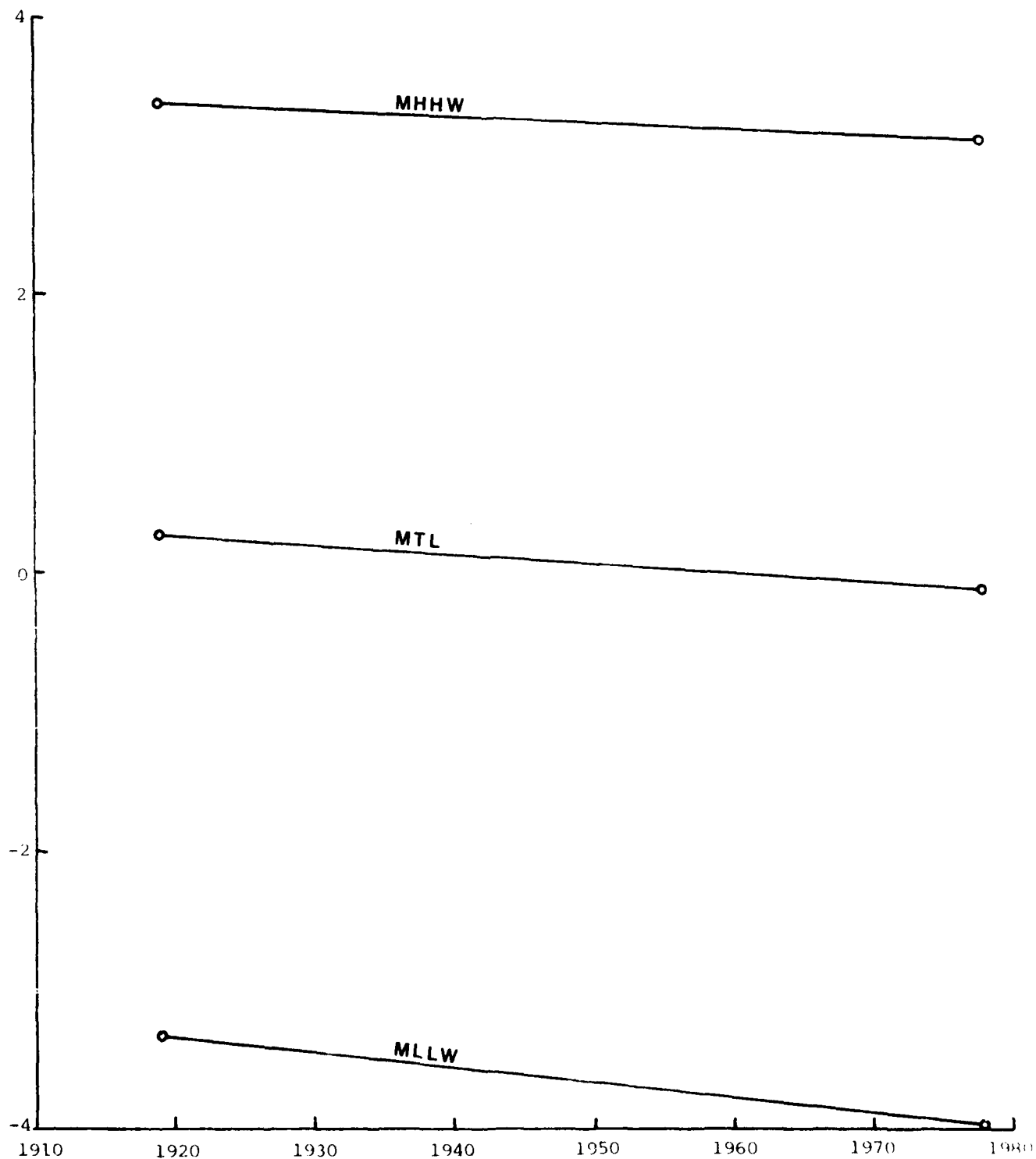
(figure developed from data in Table VI-3)

Figure VI-16

HISTORIC VARIATIONS IN TIDAL DATUMS AND RANGES

range or mean tide level. All other stations have shown an increase. For only one station, Eureka, is there data indicating historic variation in tidal datums with respect to NGVD (Figure VI-17). The data suggest a fall in mean tide level at Eureka of approximately 0.4 feet between 1919 and 1978, or 0.0067 feet per year. This is in approximate agreement with yearly mean sea level trends calculated for Crescent City (Hicks and Shofnos, 1965). It must also be remembered that historic variation in NGVD-MLLW, as calculated by NOAA, is "probably due to a combination of factors, mainly different length of tide series and control station used for computing mean values; also changes in range and sea level..." (J.R. Hubbard, NOAA, personal communication, 1 March 1979).

In summary, mean tide range and mean tide level increase with distance from the inlet into North Bay, but not significantly into South Bay. This increase appears to be due primarily to a drop in low water elevation with respect to NGVD. The tide moves more slowly into North Bay than South Bay. In addition, low tide at Eureka lags that at Samoa significantly. Finally, mean tide range appears to have been increasing at several stations within the Bay over the last 60 years. This increase in tide range has apparently been accompanied by a relative "sea level fall" at Eureka. A more detailed investigation of tide gauge records will be necessary in order to clarify and verify these interpretations.



HISTORIC VARIATIONS IN TIDAL DATUMS
WITH RESPECT TO NGVD AT EUREKA

Figure VI-17

Source: Table VI-3

H. HYDROLOGY

Several authors have suggested that Humboldt Bay is the result of the linkage of three coastal estuaries linked together by the formation of a barrier spit (Thompson, 1971; Skeesick, 1963; Ogle, 1953). The major freshwater sources were the Mad, Eel, and Elk Rivers. Gradually, all but the Elk River eroded new channels and now discharge directly to the ocean. Generally, they no longer discharge directly to the bay; the exception occurs when the Mad River floods and overflows into Arcata Bay.

The drainage basin affecting Humboldt Bay is quite small for a bay of this size. Only about 213 square miles of drainage basin directly affects Humboldt Bay, of this about 12% (24 sq. miles) is direct precipitation on Humboldt Bay. The river drainage goes primarily into Arcata Bay (85%) with the remaining runoff flowing into South Bay.

Only Elk River and Jacoby Creek have been gaged for a long enough period to estimate seasonal cycles. The monthly runoff follows the monthly precipitation quite closely with the high runoff during November-March and with a minimum during summer. The only time during the year when runoff does not follow the precipitation exactly, is at the beginning of the fall rainy season when the drainage basin is retaining a higher percentage of the precipitation in the soil following the summer drought.

The runoff into Humboldt Bay has extremely large fluctuations depending on the precipitation. The runoff may change by a factor of 100 in two days due to a rain storm. Thompson (1971) estimated (and USGS, 1979 data verifies) that the discharge for Jacoby Creek and Elk River annually averages $13.1 \times 10^6 \text{ m}^3$ and $73.1 \times 10^6 \text{ m}^3$, respectively. Additionally, he estimated a discharge to the Bay of $9 \times 10^4 \text{ m}^3$ from Freshwater and Salmon Creeks.

The Corps of Engineers (1974) estimated the mean annual maximum flow for Jacoby Creek to be 737 cfs. With a range of peak flows between 380 cfs and 2,510 cfs for the period of record (Table VI-5). U.S. Geological Survey (1970) data for Elk River indicate maxima to range between 1,510 cfs and 3,430 cfs. Musselman et al., 1978, estimated the flow entering the bay through the tidal inlet at 122,000 cfs. (Unfortunately, this estimate did not indicate when, where, or at what point in the tidal cycle this flow occurred.)

Thus, while it is apparent that the freshwater discharges into the bay may produce localized or temporary (flooding) influence, on an annual average, however, their influence is minor in terms of hydrology and hydraulics.

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HUMBOLDT BAY WETLANDS REVIEW AND BAYLANDS ANALYSIS. VOLUME II. --ETC(U)

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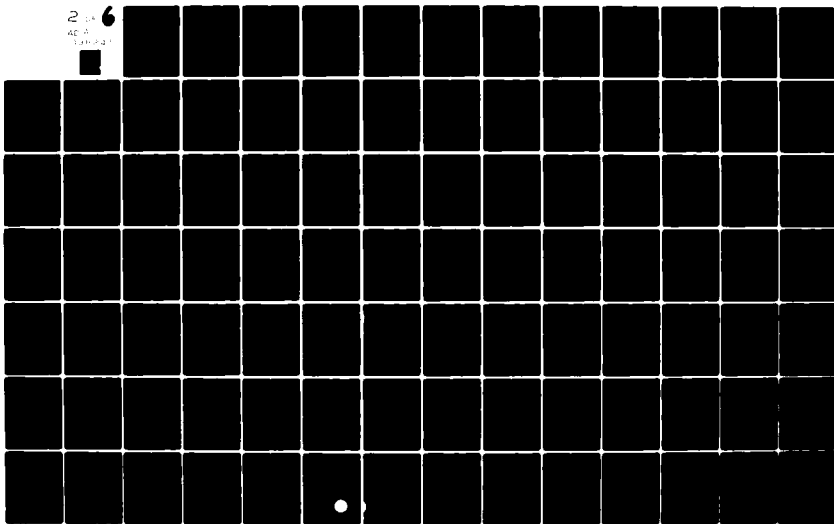
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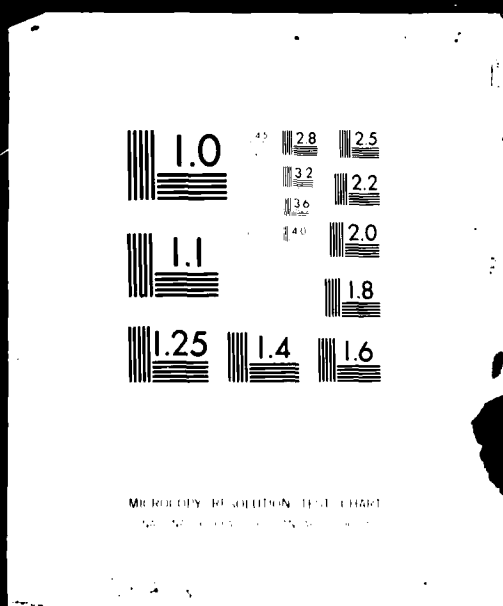


Table VI-5

ANNUAL PEAK DISCHARGE FOR JACOBY CREEK
FRESHWATER CREEK FLOOD PLAIN INFORMATION STUDY
HUMBOLDT COUNTY, CALIFORNIA

<u>Water Year</u>	<u>Date of Peak</u>	<u>Peak Discharge (c.f.s.)</u>	<u>Overall Rank</u>
1955	12/30/54	1,670	2
1956	12/21/55	1,490	4
1957	12/11/56	516	13
1958	11/13/57	729	10
1959	02/14/59	749	9
1960	02/08/60	644	11
1961	02/11/61	276	19
1962	01/19/62	389	16
1963	12/02/62	446	15
1964	01/20/64	900	7
1965	12/22/64	1,530	3
1966	01/04/66	464	14
1967	12/04/66	380	17
1968	01/15/68	380	18
1969	01/13/69	626	12
1970	01/23/70	897	8
1971	11/24/70	936	6
1972	03/02/72	2,510	1
1973*			
1974	01/16/74	1,170 est.**	5

c.f.s. cubic feet per second

* Station destroyed during 1973 high water,
no estimate of peak discharge.

** From flood marks.

Source: U.S. Army Corps of Engineers, 1974. Report on Standard
Project Flood and Intermediate Regional Flood Determination.
USACOE. San Francisco District, mimeo, 14 pp.

Tidal currents are the primary motivating force in the bay with respect to flushing, currents, and sediment disposition (Hannum, 1974). Visual observations of the dispersal of dye released near the Arcata wastewater oxidation pond suggested that waters in upper Arcata Bay move to mid-bay on a moderate ebb tide followed by some mixing with adjacent waters. PG&E estimates suggest that 44% of the Arcata (North) Bay water is replaced during each lunar day (versus 41% for the entire bay) (PG&E, 1961). Gast and Skeesick (1964) noted that flushing varies considerably with tidal prism and freshwater input. The estimated complete replacement occurs each 15 tidal cycles (7.5 lunar days) while Casebier and Toimel (1973) estimated flushing time to be 2.1 tidal cycles. Obviously, some of the peripheral areas within the bay do not flush as rapidly as the main channels.

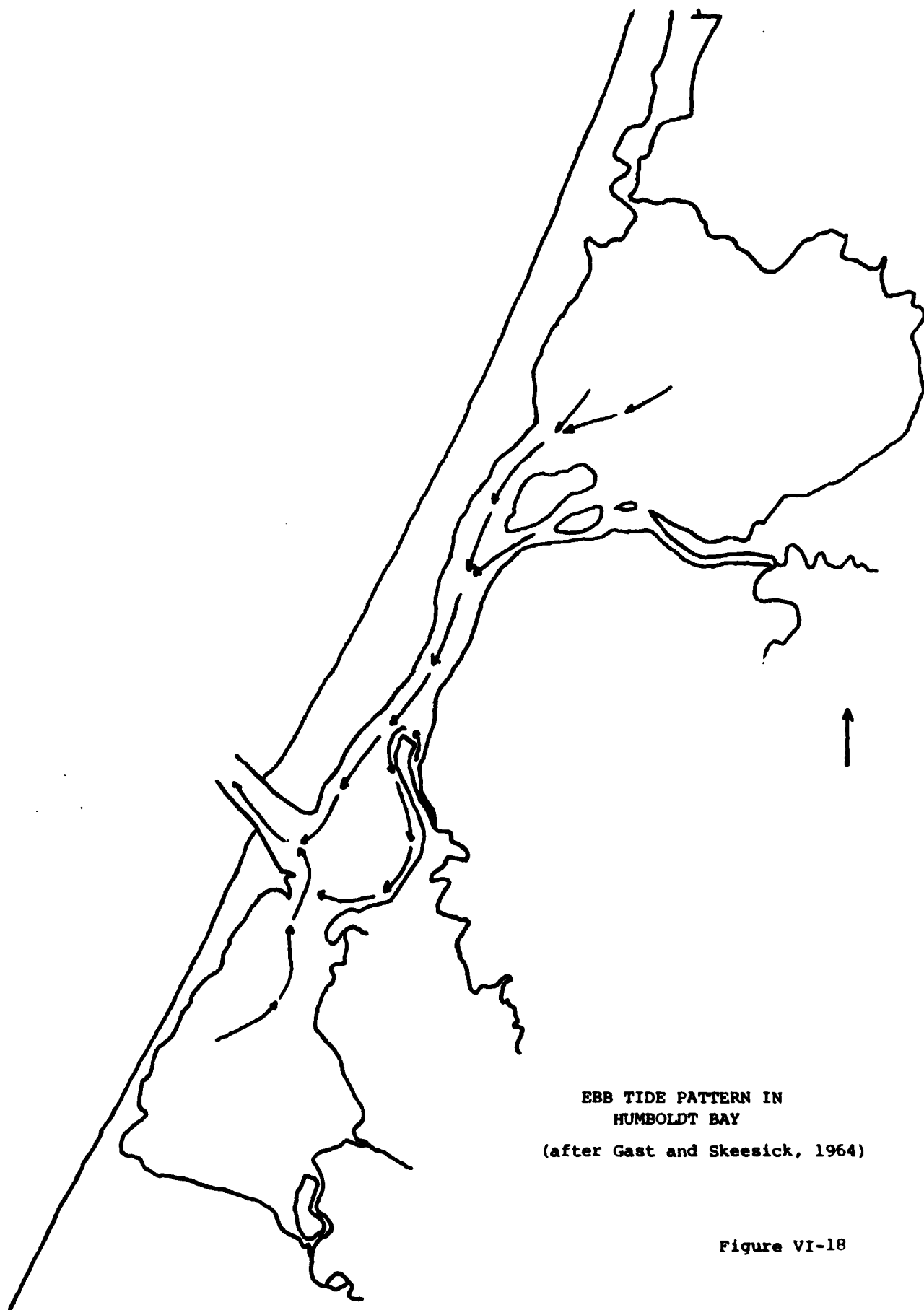
As indicated in previous sections, the bay is physically three separate units, each of which occupies the seaward end of one or more stream valleys. The flushing and current characteristics are similarly quite diverse for Arcata (North) Bay, Entrance Bay and South Bay. Flushing times and/or diffusion measurements for Entrance Bay or South Bay are not available (ERC, 1974); however, PG&E (1961), utilizing area capacity curves, suggest that during each lunar day, replacement water flushes 23% and 52% of Entrance and South Bay, respectively.

Current patterns within the bay are not well understood (COE, 1976(2)). The currents are strongest in the channels and decrease with increased distance from the mouth. Gast and Skeesick (1964) provided generalized circulation patterns for the bay (Figures VI-18, 19). They noted little difference in water movement through the water column with the exception that surface waters moved "a little faster than the deeper waters."

Water entering the bay during flood tide impinges on the shoal area on the east side of Entrance Bay. This causes upwelling in this location diverging north and south along the eastern shore (temperatures are typically 0.2-0.3°C lower than the remainder of the bay).

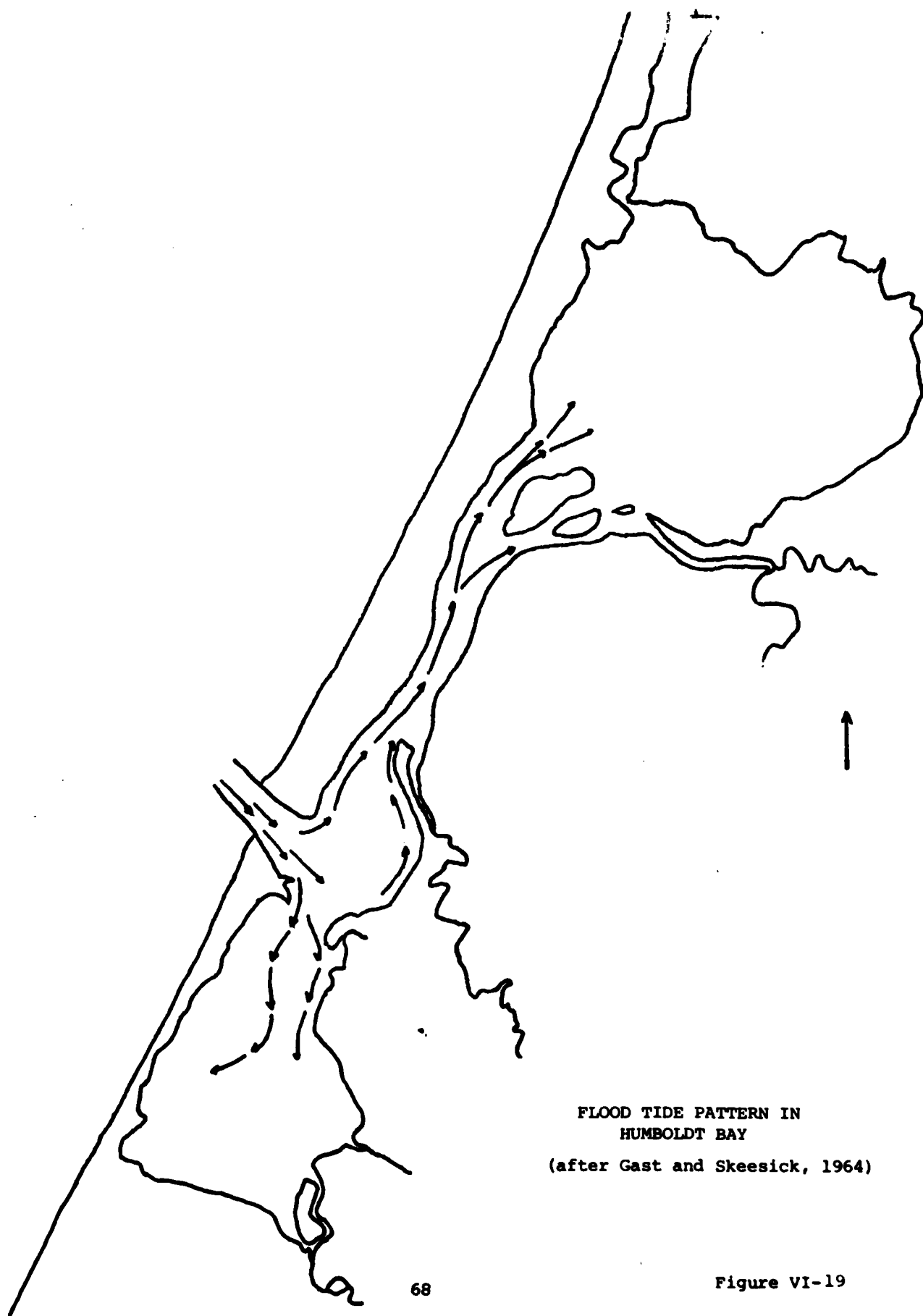
The northerly inflowing water joins the Elk River discharge and moves toward Eureka. This flow remains relatively separate from the main channel flows. During the ebb, this water moves from Eureka and Elk River to join the flow from South Bay.

Gingerich (1971) discussed the hydraulics of Eureka and Freshwater Sloughs which drain into southeastern Arcata Bay. Because of the shallow depths of the sloughs and the large tidal prism in adjacent Humboldt Bay, large fluctuations in elevation are noted semidiurnally. Similarly because of this, the water columns are well mixed vertically and horizontally; salinity decreases with distance from the bay.



EBB TIDE PATTERN IN
HUMBOLDT BAY
(after Gast and Skeesick, 1964)

Figure VI-18



FLOOD TIDE PATTERN IN
HUMBOLDT BAY
(after Gast and Skeesick, 1964)

During periods of high precipitation runoff the sloughs are stratified vertically and horizontally and salinity decreases with distance from the bay entrance. During low precipitation runoff, the tidal sloughs are well mixed and unstratified. Mad River slough is unique among all other sloughs in the bay as fresh water input only occurs with precipitation. During times of precipitation (November-April), the water column is stratified and temperature and salinity is lower in the slough than the bay. During low precipitation (May-October), the slough has higher temperatures than the bay and salinity equal to or higher than the bay (Melvin, 1979, personal communication).

Samoa Channel drains approximately 66% of the tidal volume of Arcata Bay with surface velocities reaching 1 knot. The inner reach of Eureka Channel carries a much smaller volume (approximately one-third of the tidal volume of Arcata Bay); similarly, the current velocities are lower. Both channels drain into North Bay Channel which connects to the Entrance Channel (with currents of 1.6 knots on the flood tide and 2.0 knots on the ebb) with the Southport and Hookton Channels of South Bay. The Southport Channel drains the western one-half of South Bay while Fields Landing Channel and Slough collects water from Salmon Creek and the eastern half of South Bay. Data on current velocities in South Bay are lacking. Comparison of the physical dimensions of South Bay and Arcata Bay suggest, however, that currents in the South Bay Channels are less than in Arcata Bay. The capacity of South Bay is approximately one-third that of Arcata Bay while the cross-sectional area of the South Bay Channels is approximately two-thirds (65%) of North Bay (Skeesick, 1963). Thus, a much smaller volume of water (one-third) moves through the channels which are relatively larger for the respective drainage area.

I. CURRENTS AND CIRCULATION

Humboldt Bay can be characterized as an elongate channel with a relatively large bay at each end and an oceanic connection in the middle. This hourglass configuration results in complex circulation patterns which are not yet fully understood. The only comprehensive physical study consisted of monthly sampling for temperature and salinity at 12 sites throughout the bay system (Skeesick, 1963; Gast and Skeesick, 1964). Several small studies have also been conducted, principally in North and/or Entrance Bays, with the intent of addressing a single problem, and not of providing a comprehensive description of circulation (PG&E, 1961; Casebier and Toimil, 1973; Beittel, 1975; Musselman, et al., 1978).

The results of these studies are the basis of this section. They include the following:

- . A characterization of the general physical features of the Bay.
- . A description of the basic temperature and salinity variations and circulation patterns of the Bay.
- . Several estimates of tidal flushing time.

In addition, a small (1:25000) physical model of the Bay was built and run as a tool to compare the results of the various studies.

GENERAL FEATURES OF THE BAY

The surface areas and volumes of the three bays for mean high water and lower low water are shown in Table VI- 6. As can be seen from this table and Plate 8, a large portion of North and South Bays consists of tidal flats which are exposed at mean lower low water. The large change in volume with the tides results in a very energetic system. Approximately 77% of the area of Humboldt Bay is tidal flats, 19% channels, and 4% salt marshes. The major channels are regularly dredged to maintain depths on the order of 35 feet. The deepest point in Humboldt Bay is -51 feet MLLW (NOAA chart 18622).

From Table VI- 6 several important features of the Bay can be identified. Almost two-thirds of the surface area of North and South Bays is intertidal in elevation, consisting of mudflats and marshes, but less than 10% of Entrance Bay is intertidal mudflats and marshes. The dearth of mudflats in Entrance Bay is probably the result of waves entering through the inlet. The jetties along the inlet appear to focus wave energy onto the eastern shore of Entrance Bay, transporting sediment away from the Bay either north or south.

Table VI-6

GENERAL CHARACTERISTICS OF HUMBOLDT BAY

	<u>South Bay</u>	<u>Entrance Bay</u>	<u>Arcata Bay</u>	<u>Humboldt Bay</u>
Area [ha (Ac)]				
MLLW	710 (1,750)	730 (1,800)	1,190 (2,940)	2,360 (650)
MHW	1,830 (4,520)	790 (1,950)	3,450 (8,520)	6,070 (1,500)
Volume ($10^7 m^3$)				
MLLW	1.24	3.21	4.80	9.29
MHW	3.70	4.44	8.51	16.65
Tidal Prism ($10^7 m^3$)	2.46	1.23	3.71	7.40
Tidal Prism/ Volume (MHW)	0.66	0.27	0.44	0.44
Average Depth				
(m)	1.7	6.1	4.0	3.5
(ft)	5.5	19.8	13.0	11.4

Source: University of Washington, 1955

This transport has probably contributed to the formation of both Elk River Spit and the spit at King Salmon from the erosion of Red Bluff.

Tidal prism is almost 2/3 of the total high water volume of South Bay, but amounts to less than half of the total high water volume of North Bay. These relationships would suggest that South Bay undergoes complete tidal flushing in a shorter time than North Bay. This will be discussed in more detail later in this section.

Finally, it would appear that Entrance Bay functions in part as a mixing area. It receives water from both North and South Bays, and through the inlet; it is also an extremely energetic area as mentioned previously. Thus, water entering Entrance Bay is probably vigorously mixed before being transported to the north, south, or west.

WATER CHARACTERISTICS

Seasonal Variations

Temperature and salinity in the Bay vary with climatic conditions and also with oceanic water characteristics outside the mouth of Humboldt Bay. These two influences are generally in opposition, minimizing seasonal fluctuations in water characteristics except at the extreme ends of the system. Figure VI-20 illustrates these fluctuations. Air temperature and freshwater runoff tend to produce colder, less saline Bay water in winter and warmer higher saline Bay water in summer.

Offshore water characteristics are controlled primarily by offshore currents and wind conditions. During the winter and early spring (November-April) predominant winds are from the south and the southwest and the northerly flowing Davidson current is pushed onshore between the coast and the southerly flowing California Current. The Davidson current carries warm water from the south and the wind carries surface water onshore, resulting in downwelling which tends to depress the pycnocline and hold freshwater close to shore. During the late spring and summer (April-August) the south flowing offshore California Current movement is strengthened as a result of prevailing northwest and north winds. Strong northwest winds cause an offshore movement of surface water; the result is the upwelling of cold, more saline water to the surface. During the late summer and early fall (August-November) northerly winds tend to slacken, upwelling decreases, and a strong vertical temperature gradient persists. Oceanic water moves onshore, resulting in higher temperature and salinities than during the summer. This season is referred to as the Oceanic period.

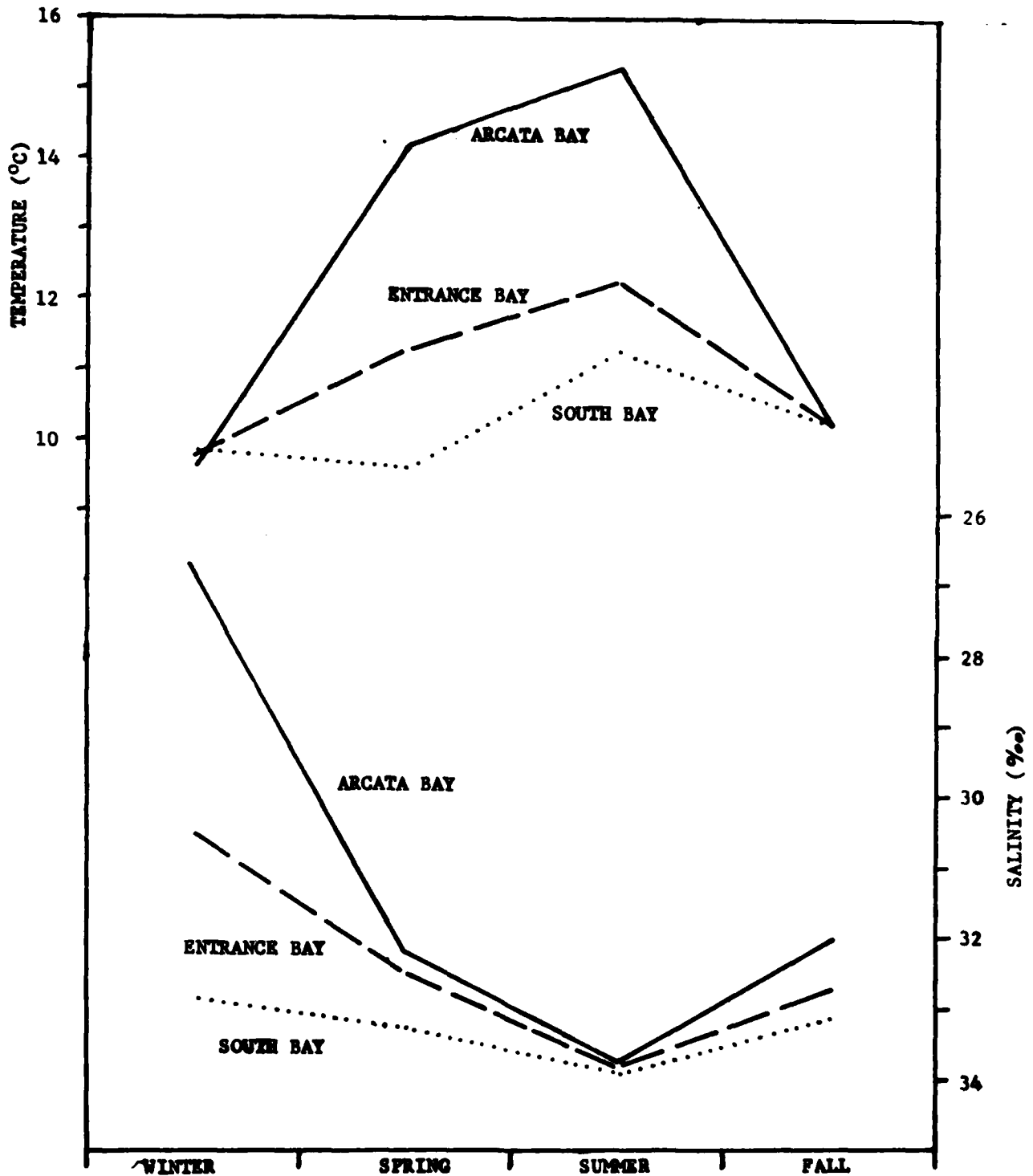
Thus, in the winter relatively warm oceanic water enters the bay and mixes with the cold, less saline Bay water. In the summer, cold, more saline water floods the Bay mixing with Bay water which has been warmed on the shallow tidal flats. It is apparent, then, that distance from the mouth of the Bay determines in part whether Bay water or oceanic water has the greatest influence on Bay water characteristics.

Horizontal Variation

In general, water temperature tends to increase from the bay mouth to the heads of the bays. (In mid-winter, however, the temperature gradient may be reversed.) The greatest temperature differential (10° - 15° C) occurs in the summer when cold, upwelled water is at the Bay mouth while Bay head waters are warmed on the tidal flats.

Salinity also varies from the bay mouth to the headwaters. In the winter, freshwater runoff depresses salinities, resulting in a salinity decrease from bay mouth to headwaters. In the summer, evaporation of headwaters results in a slight increase in salinity

Figure VI-20



Seasonal cycles of temperature and salinity based on all available data (Gast and Skeesick (1964), Beittel (1975), Gibbs (1972), Icanberry (1971), McBee (1971), Musselman, et al. (1978), and Humboldt State College (1958-1963).

and, therefore, an increasing gradient from the mouth. Figure VI-21 shows these two salinity gradients (Skeesick, 1963).

Saline bay water also intrudes up the rivers and creeks entering the Bay, such as Elk River and Eureka Slough/Freshwater Creek. The maximum extent and character of this intrusion is dependent primarily on river discharge. During low freshwater discharge situations, saline waters achieve maximum upstream penetration, about 4 miles above the mouth in Elk River and 3 miles in Eureka Slough/Freshwater Creek (Davidson, 1977). Under these conditions the water column is well mixed, with little variation in salinity from surface to bottom. During periods of high freshwater discharge, saline water does not intrude as far upstream. In addition, there is also a salt wedge effect, with freshwater on the surface, saline water on the bottom and little mixing between the two (Gibbs, 1972; West, 1972),

CIRCULATION

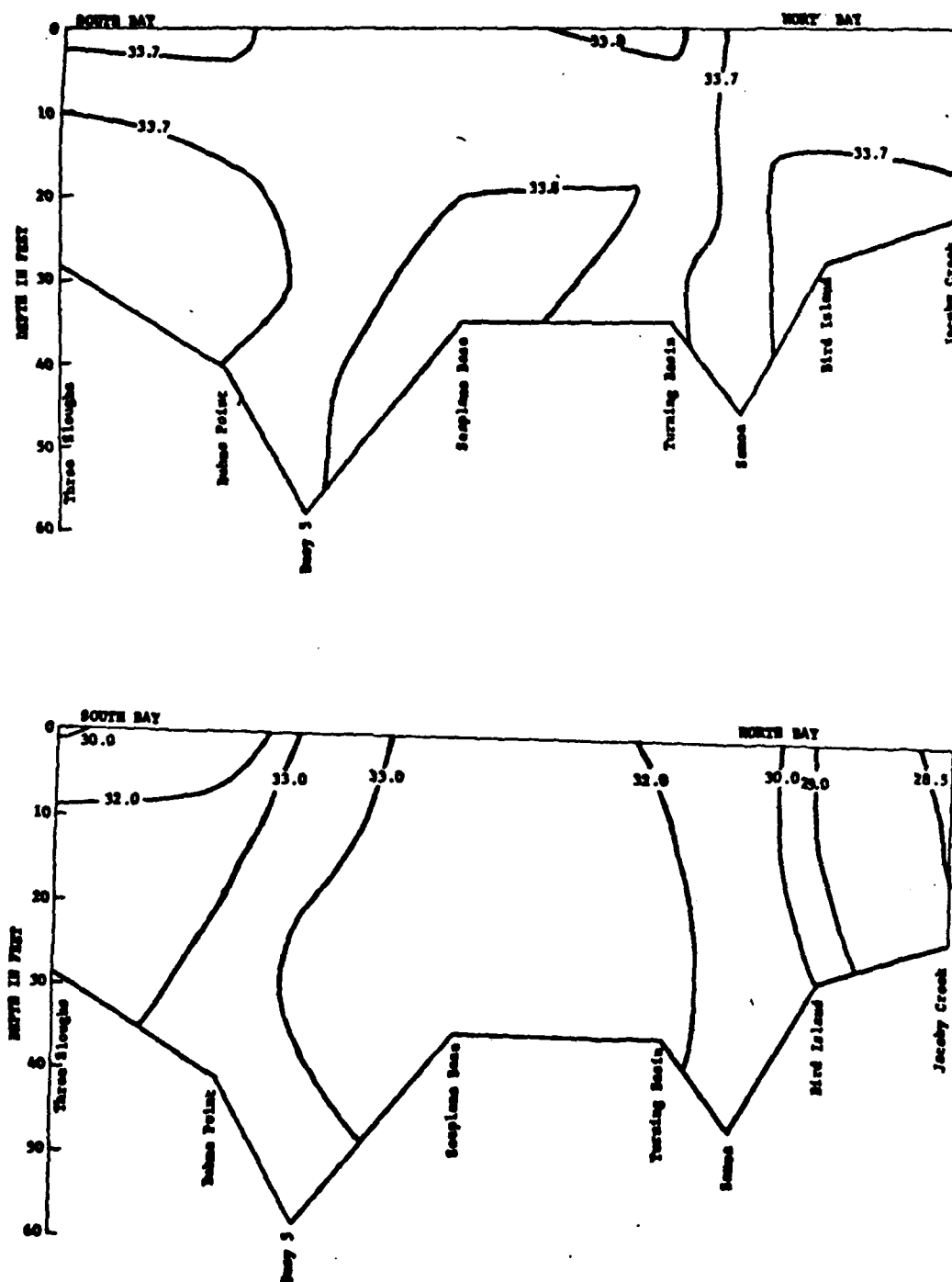
Patterns of tidal circulation in the Bay were first described by Gast and Skeesick (1964). The flood and ebb tidal circulation patterns they described are illustrated in Figures VI-18, 19. These patterns only describe flows in the main channels, however. They do not provide detailed descriptions of flow in smaller channels or across intertidal flats. They also only give estimates of water velocities in the main channels. Finally, they are based on data collected during the highest tide of the month and, therefore, do not necessarily represent average conditions.

Two small scale dye studies have been conducted in North Bay in an effort to determine in part the rate of discharge from the Arcata Sewage Treatment Plant (Hannum, 1974; Hannum, unpub. MS). No quantitative studies were conducted; dye discharged near the sewage plant was monitored aerially. The results suggested that water over the intertidal flats near Arcata is not readily exported from the Bay, but rather is transported to the Bay perimeter and slowly diluted.

In an effort to acquire a more detailed description of circulation in Humboldt Bay, a small (1:25000) physical model of the Bay was constructed. (The details of scaling factors and construction of the model can be found in Appendix E-8). It was understood that such a model would have some limitations, in particular the lack of adequate data to provide anything but relative verification. It was nonetheless hoped that the model would provide a qualitative view of tidal circulation and flushing that does not exist elsewhere. The results of model investigations are discussed below.

Dye was injected at nine points in the model, and its movement traced for several tidal cycles. Flood and ebb movements are plotted on Figures VI-22, 23. Several interesting phenomena were observed.

Figure VI-21



Horizontal variability of salinity in the main channels of Humboldt Bay for October, 1961 (top) and February, 1962 (bottom). The data was taken at Higher High Water. (Skeesick, 1963)

Figure VI-22
Results of Model Dye Studies - Flood Tide

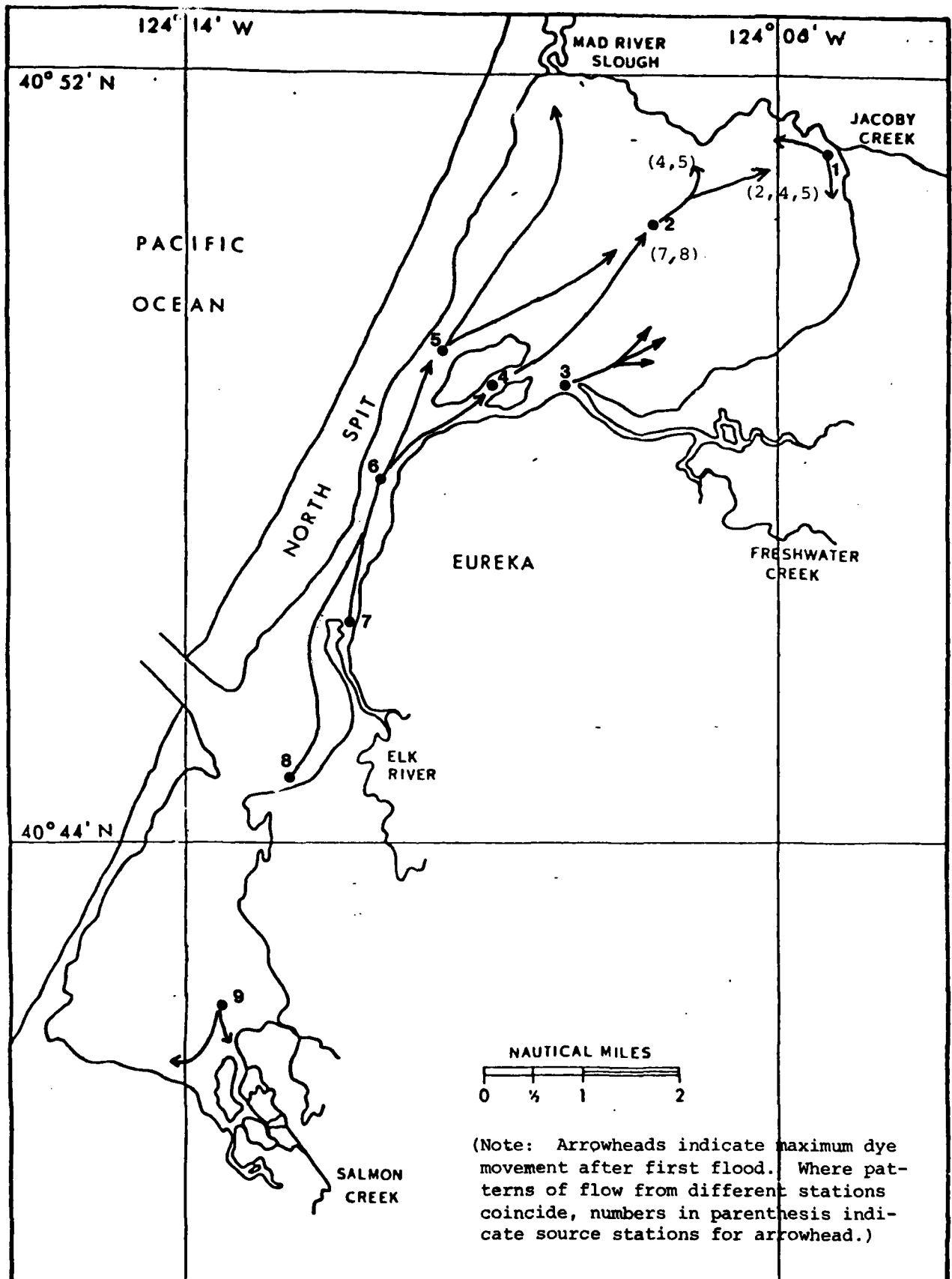
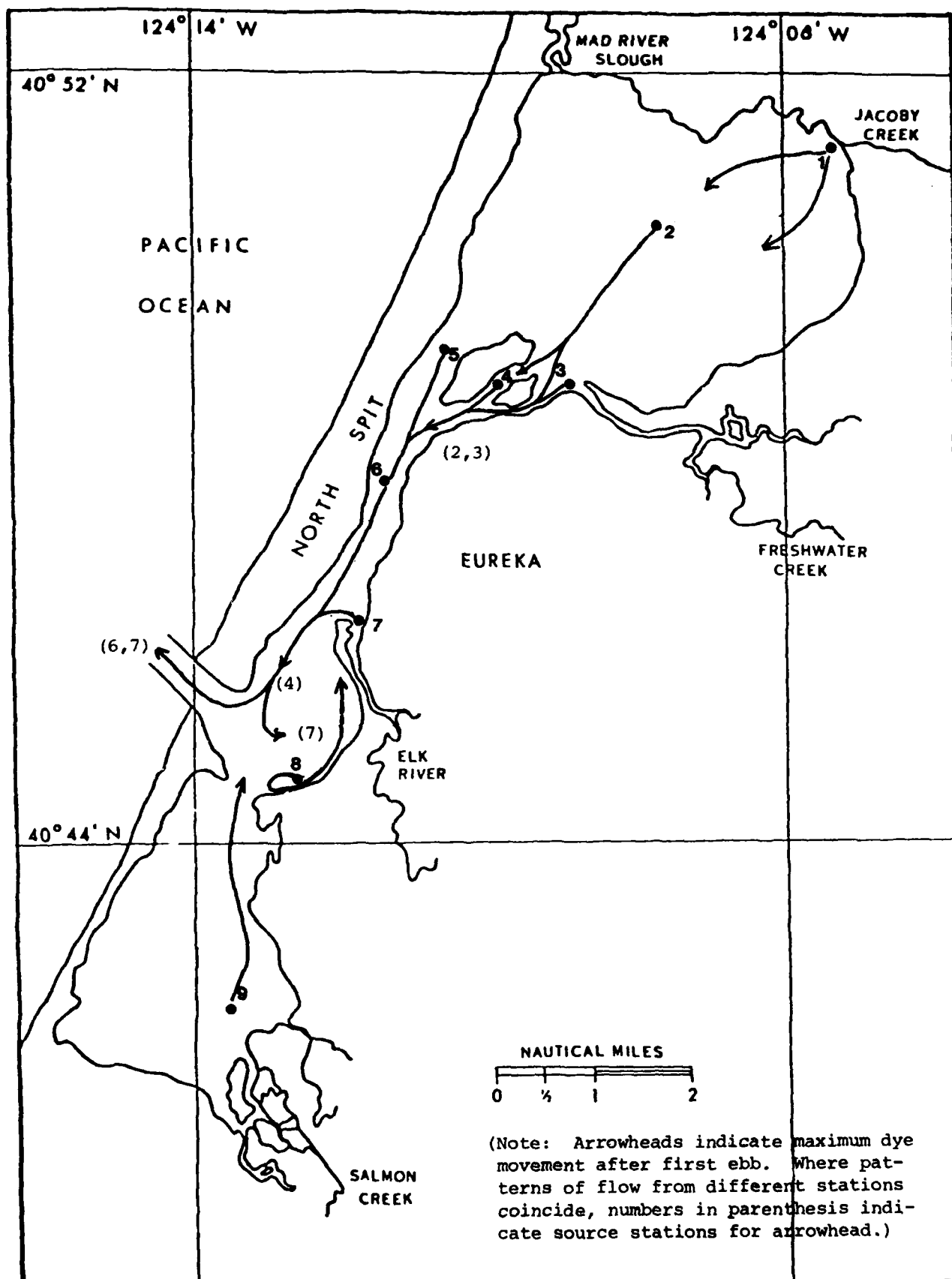


Figure VI-23
Results of Model Dye Studies - Ebb Tide



- 1) On a flood tide, dye near the headwaters of North Bay channels was moved onto the flats and somewhat uniformly distributed about the perimeter of the Bay.
- 2) Dye within the channels, especially in North and Entrance Bays, often flowed back and forth for several tidal cycles without significant dispersion or transport out of the Bay.
- 3) A counterclockwise eddy developed in Entrance Bay during ebb tide, trapping some dye rather than allowing it to escape out the inlet.
- 4) Some dye near the mouth of Hookton Slough moved westward along the south shore of South Bay and then northward along the west shore, ultimately entering Southport Channel and being transported from the Bay.

Point (1) generally agrees with the dye studies of Hannum (1977). Point (2) would appear to suggest compartmentalization of water in the Bay such as that suggested by Beittel (1975). The observations of Point (3) appear to conflict with the results of Gast and Skeesick (1964) although the extent of their current data in Entrance Bay is not known. Thompson (1971) has suggested a situation similar to that described in Point (4) to explain the motion of giant sand waves along the west side of South Bay.

A second model experiment involved dyeing the water black and then sprinkling bronze dust on the surface. Time exposure photographs then display patterns of surface water movement. Figures VI-24 to 29 illustrate the circulation patterns observed in the photographs. Figure VI-30 designates the point of time within the tidal cycle to which each illustration corresponds.

At the beginning of flood incoming water bifurcates, moving into both North and South Bays. In North Bay the relative flow or net velocity (i.e. volume/cross-sectional area) appears uniformly divided between the three main channels; in South Bay the split between Fields Landing and Southport Channel also appears even. Numerous eddies form as water moves from the channels onto the flats.

By the peak of flood, the proportion of flow into South Bay has decreased. A counterclockwise eddy has developed along the west side of Entrance Bay, all flow to North Bay is east of the eddy along Elk River Spit. An eddy also formed in Eureka Channel near Indian Island, increasing flow up Samoa Channel. In South Bay water movement is restricted primarily to the channels.

As the end of flood and highwater slack occur, water movement is limited mostly to eddies. The Entrance Bay eddy fills most of that Bay.

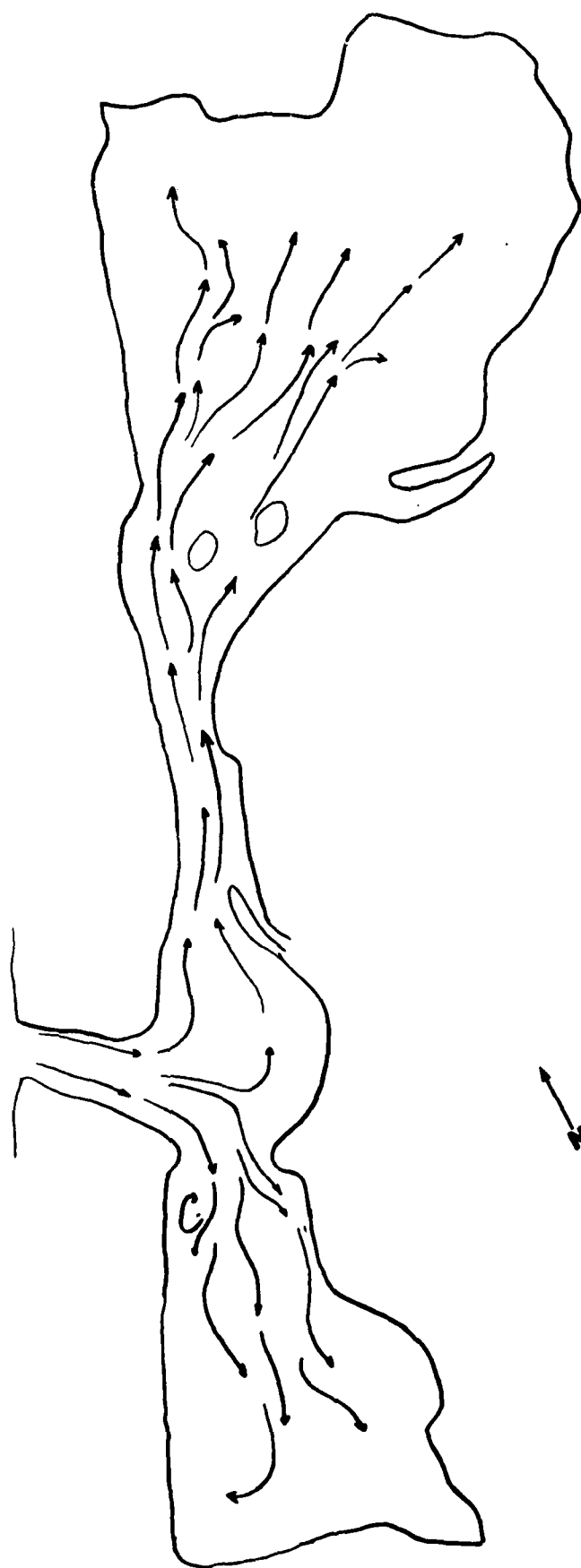


Figure VI-24

PHYSICAL MODEL CIRCULATION PATTERN AT BEGINNING OF FLOOD

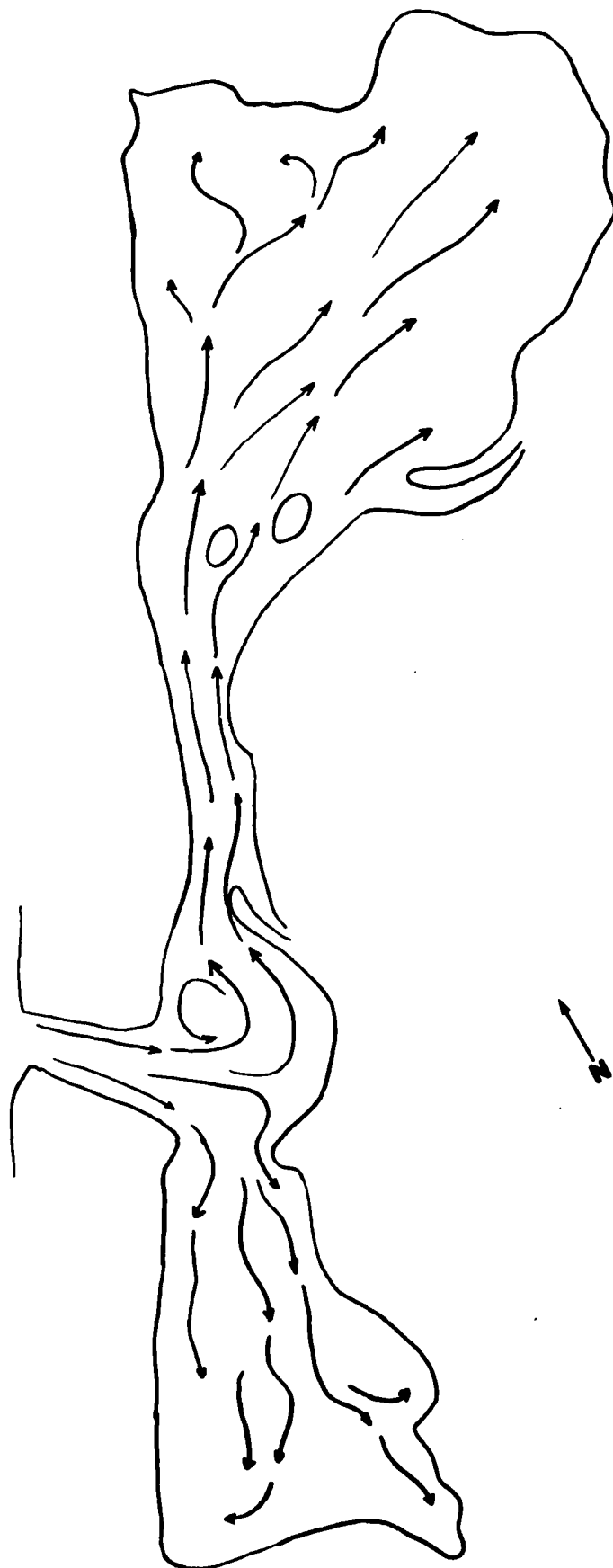


Figure VI-25

PHYSICAL MODEL CIRCULATION PATTERN AT MIDDLE OF FLOOD

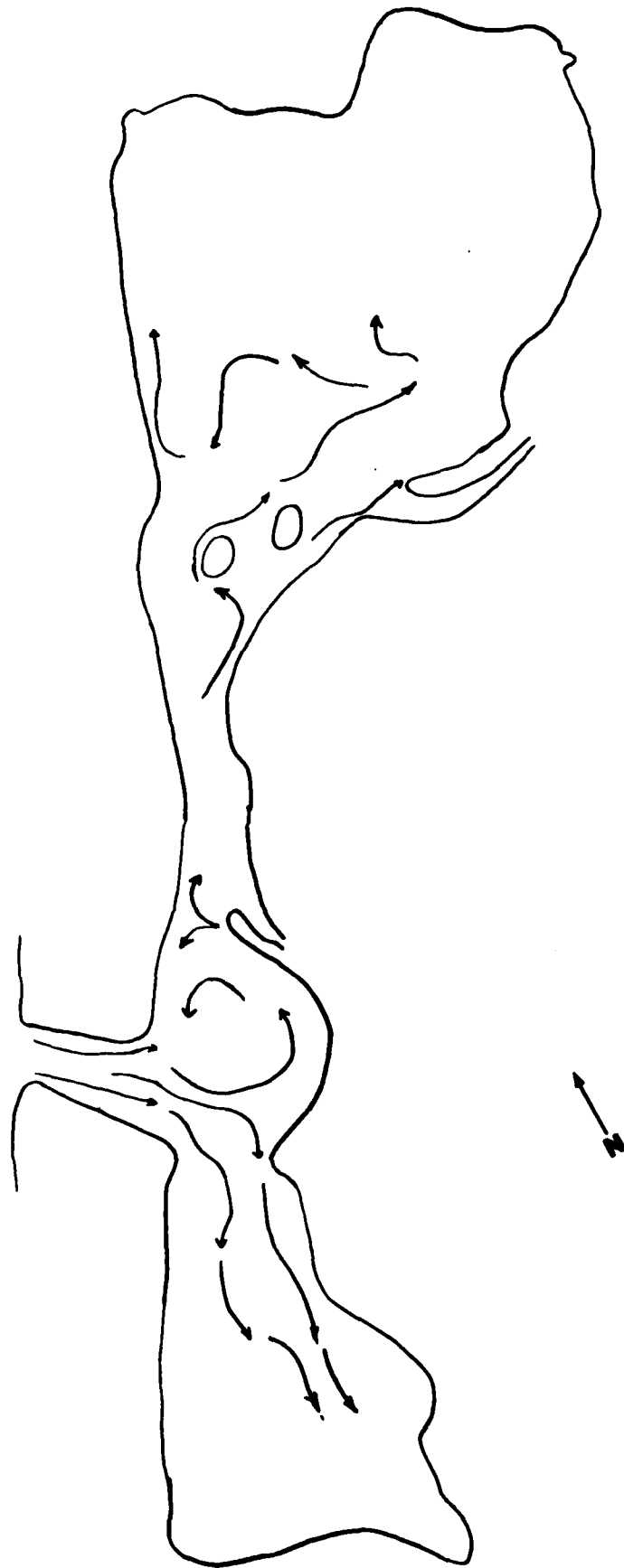


Figure VI-26

PHYSICAL MODEL CIRCULATION PATTERN AT END OF FLOOD

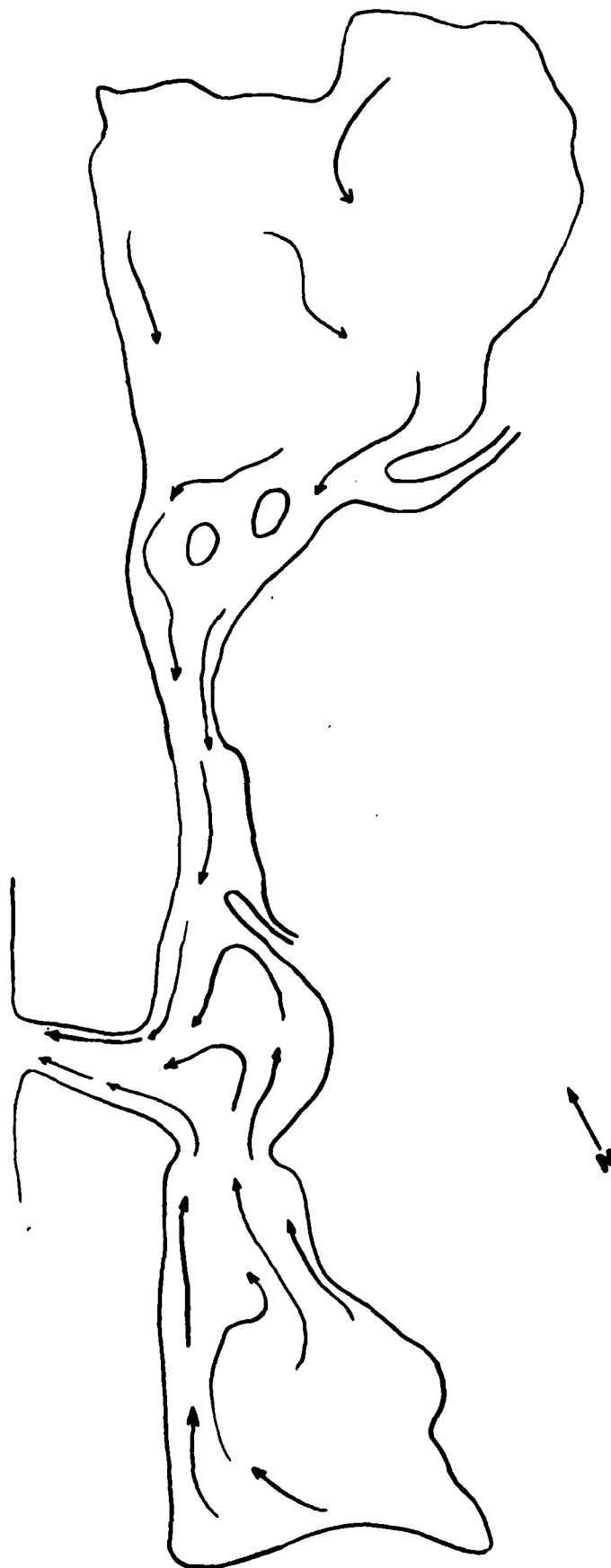


Figure VI-27

PHYSICAL MODEL CIRCULATION PATTERN AT BEGINNING OF EBB

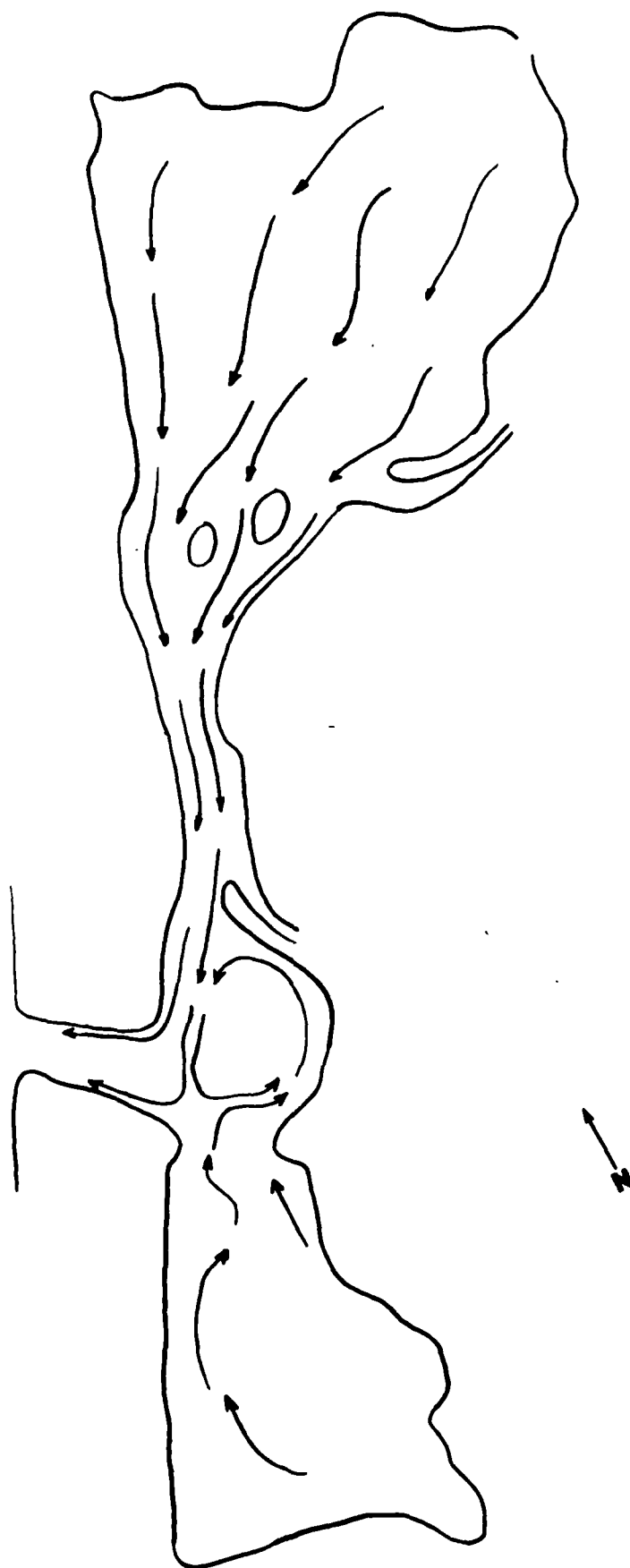


Figure VI-28

PHYSICAL MODEL CIRCULATION PATTERN AT MIDDLE OF EBB

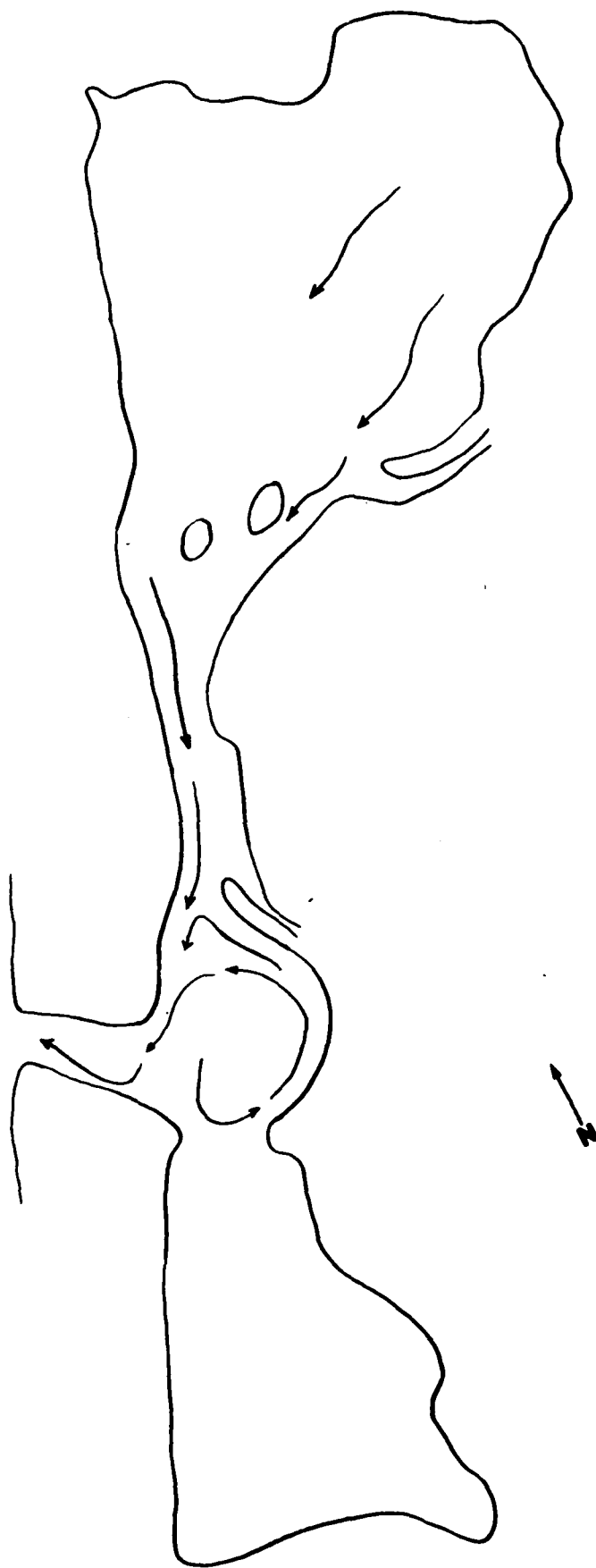
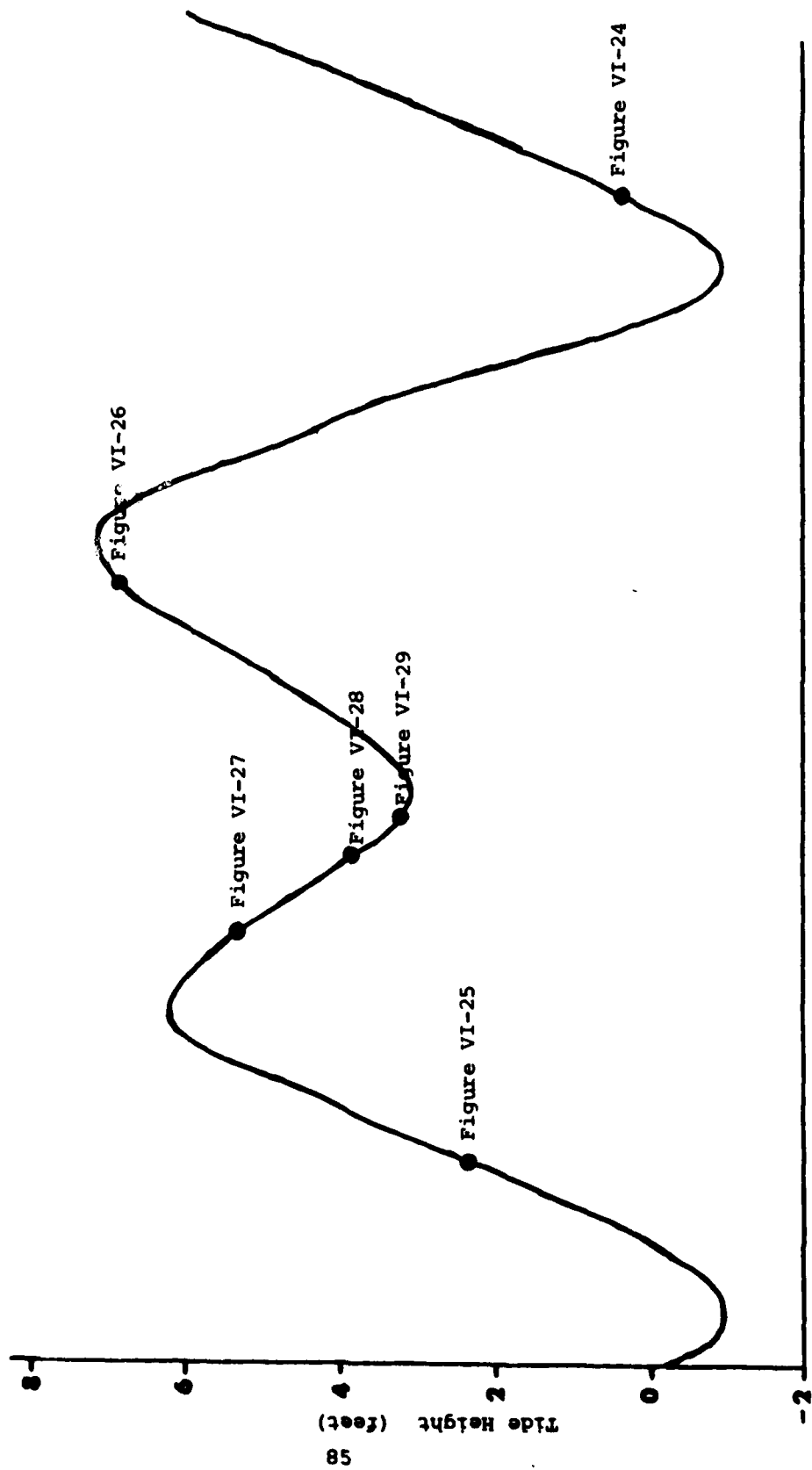


Figure VI-29

PHYSICAL MODEL CIRCULATION PATTERN AT END OF EBB



LOCATION OF ILLUSTRATIONS IN THE TIDAL CYCLE

Figure VI-30

At the beginning of ebb, much of the water leaving the inlet is from South Bay. By the middle of ebb, however, North Bay water dominates the flow through the inlet, while much of South Bay flow is incorporated in an eddy occupying the eastern portion of Entrance Bay. Small eddies have also formed in the lee of Indian Island. At the end of ebb, flow has stopped throughout most of the Bay system and the Entrance Bay eddy again fills the entire Bay. It should be noted that PG&E (1973) released drogues in Entrance Bay to determine the potential path of cooling water. Unfortunately, these drogues were only left in for 0.5 to 1.5 hours, and provide neither confirmation nor refutation of the presence of an eddy in Entrance Bay. Although the results of Gast and Skeesick (1964) conflict with those of the model, there are no published data on which to base comparisons.

TIDAL FLUSHING

Several estimates of the flushing time, or the period necessary for complete replacement, of Humboldt Bay waters have been suggested. Gast and Skeesick (1964) noted that flushing may vary with the tide and freshwater runoff, but on the average it occurred every 15 tidal cycles. PG&E (1961) suggested that 44% of North Bay water is replaced in a lunar day. (Assuming complete mixing, this amounts to about 99% replacement in seven lunar days, or about 14 tidal cycles.) In contrast, Casebeir and Toimel (1973) suggest a flushing time of 7.1 tidal cycles based on an assumption of tidal mixing.

Beittel (1975) suggested there were two water compartments in the Bay and minimal mixing between them. The neretic, or ocean, water compartment filled the channels at high tide and ebbed toward the Bay mouth at low tide. The Bay water compartment was situated over the intertidal flats at high tide and ebbed into the channels at low tide.

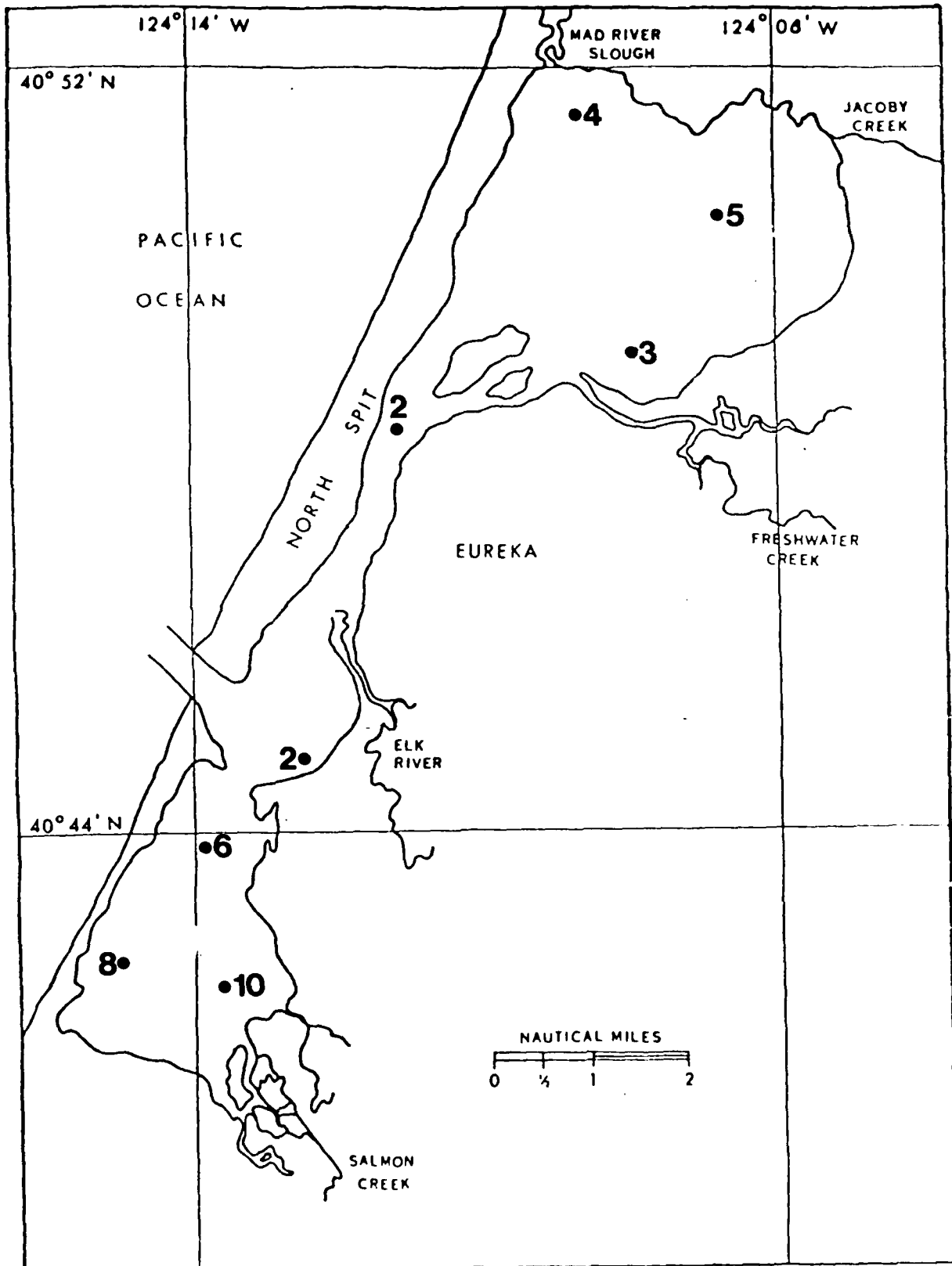
An estimate of flushing was also made by placing small floating pellets in the physical model and observing how long it took for them to leave the Bay. In each test, 20 pellets were released and the time (in lunar days) was determined for each pellet to leave the Bay. Eight sites were chosen; each site was tested at least three times at both high and low water. The results of this test are shown in Figure VI-31.

Several interesting features were observed:

- . Pellets released at high water exited faster than those released at low water. Those released at low water were carried onto the intertidal flats during the following flood.

Figure VI-31

Average Time (days) for Pellets to Exit Humboldt Bay Model from Various Locations in Humboldt Bay



- . Pellets released at the northeast corners of North and South Bays took longer to exit than those released from any other point in the respective Bay.
- . Pellets from South Bay exited into Entrance Bay relatively quickly, but rather than being flushed immediately out into the inlet, 2/3 of them were transported into North Bay on the following flood.

SUMMARY

Humboldt Bay is an irregularly shaped embayment characterized by extensive intertidal mudflats dissected by deep tidal channels. Climatic and nearby oceanic conditions result in minimum temperature and salinity in the winter and maximum temperature and salinity in the summer. Temperature tends to increase from Bay mouth to the heads of the Bays. Salinity tends to decrease from Bay mouth to Bay head in winter, and to increase slightly in summer. Circulation has been described using both field data and a small physical model. Of interest is an eddy observed in Entrance Bay in the model which is not suggested by any field data, but contradicts earlier descriptions of circulation.

ADDENDUM

Following completion of the draft document, the investigators who developed the previously described physical model, conducted field studies in Entrance Bay. Working with staff of the Humboldt State University Department of Oceanography, they investigated the various phenomena observed in the model. The following section is a summary of their results; it is excerpted from the first draft of a paper entitled "Tidally Pumped Exchange Between Two Interconnected Shallow Bays: Humboldt Bay, California" by Curtis C. Ebbesmeyer, Steven L. Costa, Carol Diebel, and Laurence R. Hinchey (in preparation).

The directions of surface currents have been observed using anchored streamers and free drifting sheets. The streamers consisted of thin rectangular sheets of polyethylene flexible plastic foam measuring approximately 1 x 3 x 0.0032 m, reinforced and weighted with venetian slats and steel plates, respectively. One end of the streamers were tethered to a float and then to an anchor. The direction of the streamers were determined at approximately 15 minute intervals from the compass of a light aircraft aligned over each streamer at approximately 50 m altitude. The drifting sheets were of similar design but measured 1.8 x 1.8 x 0.0032 m. Each streamer and sheet

were individually coded (see Ebbesmeyer, et al., 1978^a for details of the field technique).

Observations of drogue movements were conducted in Entrance Bay by the U.S. Army Corps of Engineers (1930)^b when its configuration was quite different from that at present. As a result, their observations have limited application to the present tidal pumping mechanism.

Some early measurements using current meters were taken prior to recent dredging activity and at a time when the configuration of Entrance Bay was significantly different from that at present. Thus, the early measurements are probably of small importance with respect to tidal pumping in the present day configuration. Recently, measurements were taken at five locations (surface and mid-depth) using moored current meters.

Tidal pumping mechanism

The surface pattern of currents associated with tidal pumping as observed on 13-14 May 1980 are shown in Figure VI-31a. On the flood tide (Figure VI-31a), coastal ocean water flows inland through Entrance Channel and diverges in Entrance Bay toward North and South Bays. On the early ebb tide, water from North and South Bays converges in Entrance Bay and exits to the ocean. At a critical time on mid ebb, some water from North Bay begins to flood into South Bay along its mouth's eastern shore while ebb currents persist along the western shore (Figure VI-31b). We conclude that water in the eastern portion of South Bay's mouth shows a predominant or net flood current; the compensatory net ebb current has been observed at surface as a predominantly ebb flow toward the northwest (Figure VI-31c). This location is near mid-channel at the interface of net ebb and flood currents. It is expected that a more westerly site will reveal a stronger net ebb current.

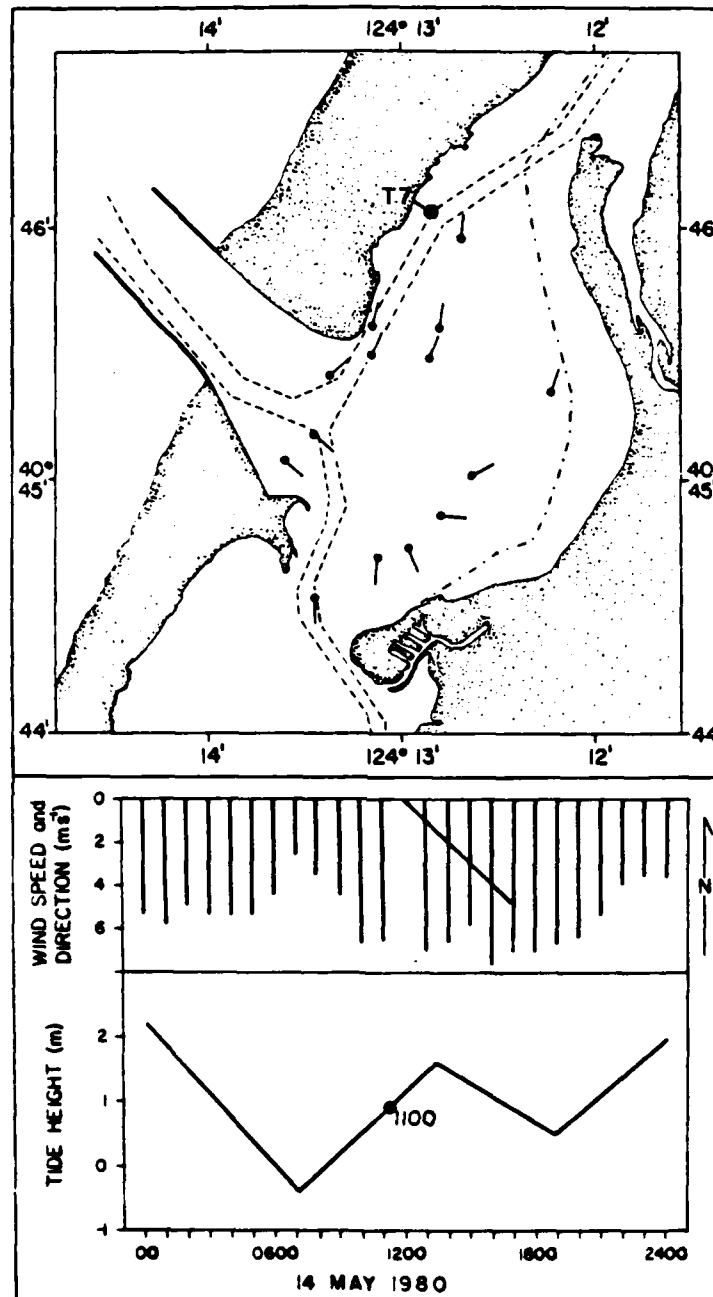
The convergence of clear North and sediment-laden South Bay waters on the ebb tide is often clearly marked by a rip line.^c In order to observe the associated flow patterns, three drift sheets were released on the ebb in North Bay Channel and subsequently followed (Figure VI-31d). The striking feature of the trajectories is the divergence point ('D' in Figure VI-31d) west of which North Bay

a) Ebbesmeyer, C.C., J.M. Cox, and J.M. Helseth. 1978. Surface Drifter Movements Observed in Port Angeles Harbor and Vicinity, April 1978. NOAA Technical Memorandum ERL MESA-31.

b) U.S. Army Corps of Engineers, San Francisco District. 1930. Surface Currents in Vicinity of Buhne Property (Entrance Area), unpublished map.

c) The rip line is also marked by significant concentrations of eelgrass from South Bay. Eelgrass covers approximately 70% of the tidal flats in South Bay whereas the tidal flats in North Bay are practically devoid of eelgrass.

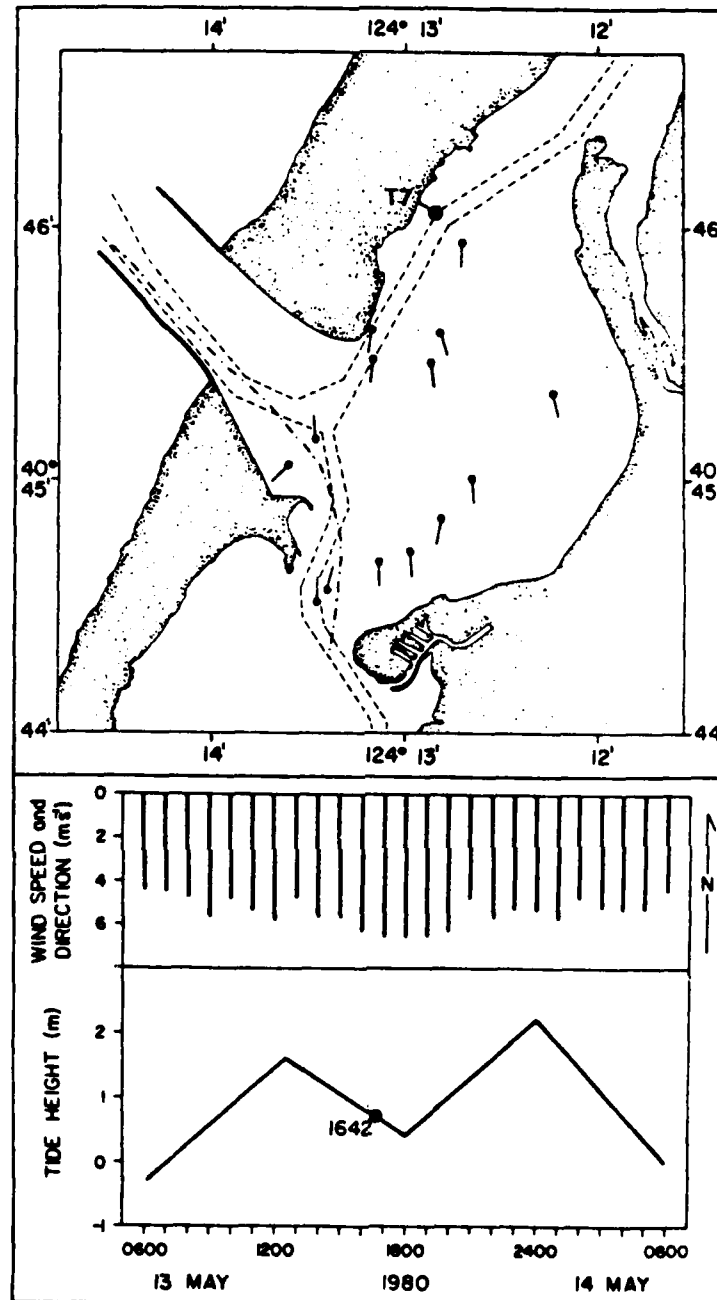
Figure VI-31a



Upper panel: plan view of current direction during mid flood tide. Dots denote the positions of the anchored streamers and 'tails' point in the direction of flow. The dashed lines indicate dredged channels and the dot-dash line in Entrance Bay denotes the boundary shoreward of which sediment laden water was observed in an aerial photograph.

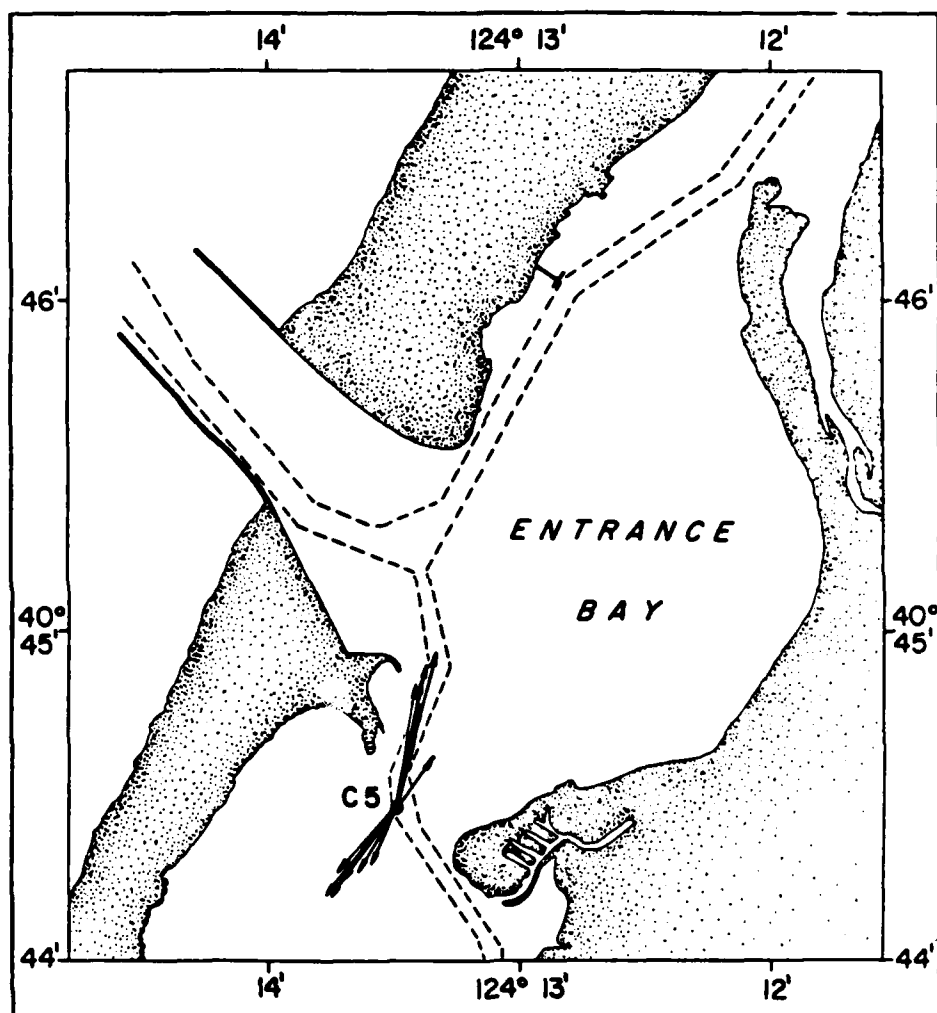
Lower panel: wind speed and direction at Eureka and tide at Site T7. The dot on the tide curve denotes the time corresponding to the upper panel.

Figure VI-31b



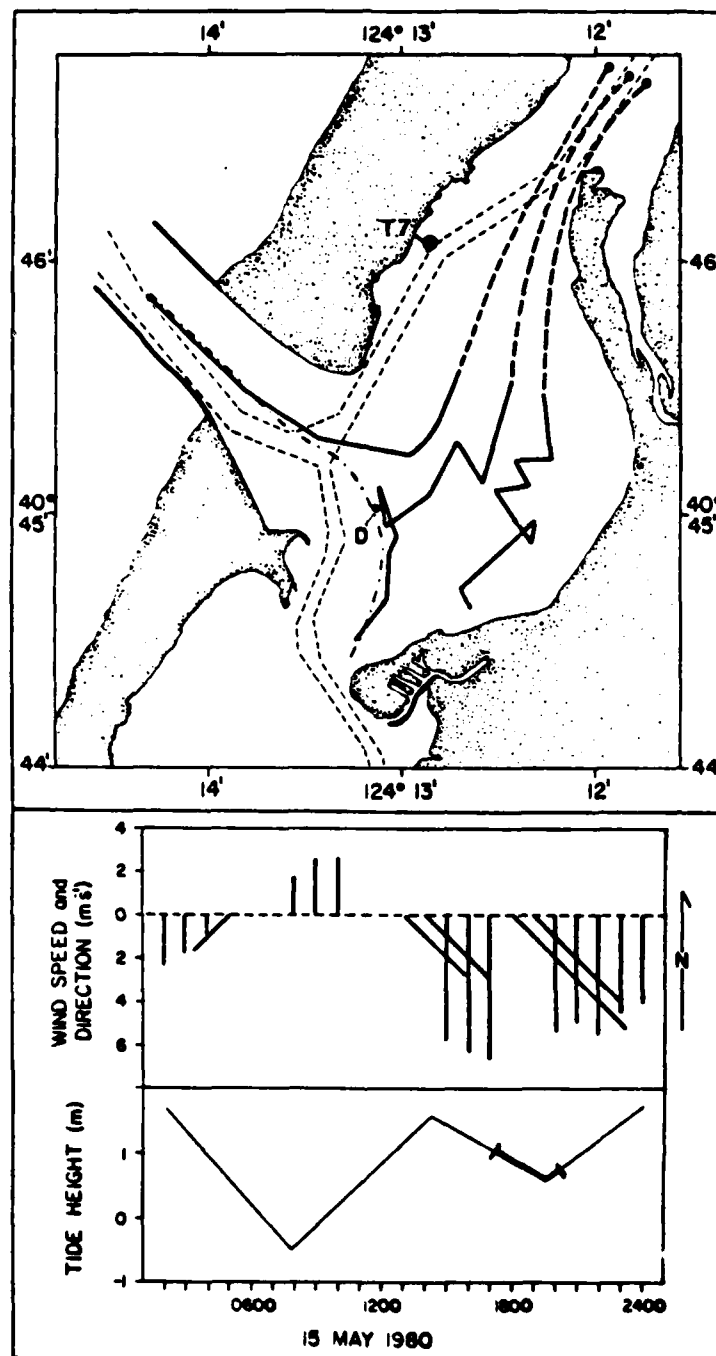
Upper panel: plan view of current direction during late ebb tide. Dots denote the positions of the anchored streamers and 'tails' point in the direction of flow. The dashed lines indicate dredged channels and dot-dash line denotes rip line. Lower panel: wind speed and direction at Eureka and tide at Site T7. The dot on the tide curve denotes the time corresponding to the upper panel.

Figure VI-31c



Flood and ebb currents observed at surface at Site C5. Dashed lines denote dredged channels.

Figure VI-31d



Upper panel: trajectories of three drift sheets released in North Bay Channel. Dots denote release sites. The dot-dash line indicates the rip line separating sediment-laden water to the south from South Bay from clearer water from North Bay. The 'D' denotes the position of horizontal divergence of North Bay water along the rip line. The dashed lines indicate dredged channels.

Lower panel: wind speed and direction at Eureka and tide at Site T7. The ticks on the tide curve denote the interval of the trajectories.

water exits to the ocean and east of which North Bay water flows into South Bay. The position of the rip line divergence suggests that the area of southerly flow along Entrance Bay's eastern shore is wide.

The divergence of the flow from North Bay Channel into Entrance Bay has been observed from a dye release. A patch of dye was released at mid-ebb near the end of Elk River Spit (California Water Quality Control Board, 1980)^d. Some dye was carried rapidly down North Bay Channel to Entrance Channel, and some moved more slowly around the eastern side of Entrance Bay (Figure VI-31e).

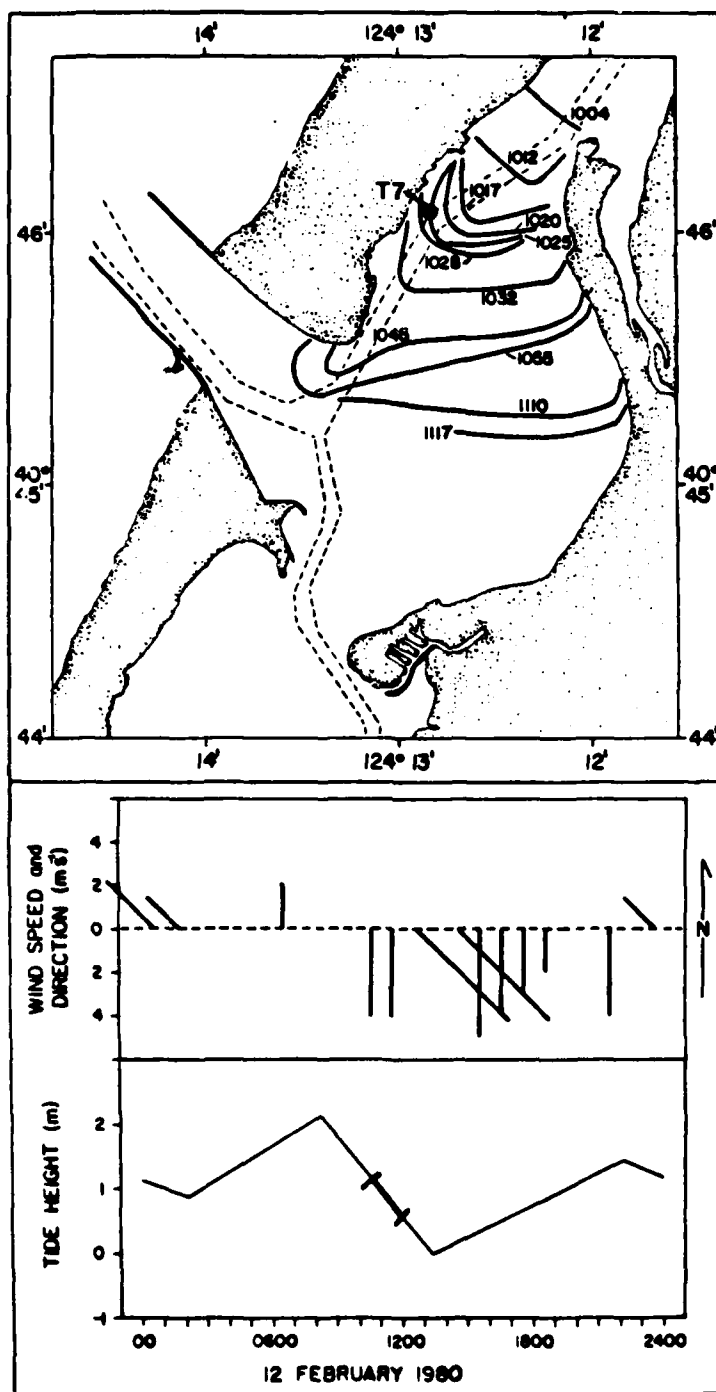
The progression of the ebb current and rip line at the mouth to South Bay has recently been observed (7 August 1980), however the data were not worked up at the time of this report. The results showed that during early ebb the flow is out of South Bay at all points across the mouth and the rip line does not extend into South Bay. Early in the ebb a flood current begins along, and the rip line separates from, the eastern shore. As the ebb progresses, the flood current broadens progressively toward the western shore; the rip line shows a corresponding progressive movement. These observations were taken in the absence of significant wind and thus confirm and supplement some aspects of the 13-15 May observations during which there occurred moderate winds from the northwest. We conclude that irrespective of wind effect, the tidal pumping mechanism acts to produce a net transport of water into South Bay.

The tides as observed at opposite ends of Humboldt Bay may provide a measure of the pressure gradient between North and South Bays. Figure VI-31f shows the tide measured at the mouth of Mad River Slough and at Fields Landing during 25 October 1979. The water level at the head of North Bay stands higher than that in South Bay from early until mid to late on the ebb tide. We speculate that friction in North Bay Channel may cause the observed phase lag. Whatever the cause, apparently during much of the ebb there is a pressure gradient which acts to drive water from North Bay into South Bay and is in apparent agreement with the observations of surface currents described earlier.

The observed tides in Figure VI-31f also show that during flood the pressure gradient reverses so as to drive water from South Bay into North Bay. While we have not observed a corresponding net transport, there is evidence from suspended sediment in aerial photographs that some South Bay water apparently traveled northward along the eastern shore of Entrance Bay (Figure VI-31a)

d) California Regional Water Quality Control Board, North Coast Region. 1980. Humboldt Bay Dye Study.

Figure VI-31e



Upper panel: progressive position of the leading edge of dye initially released in North Bay Channel during 12 Feb. 1980. Numbers indicate times of dye observation. Dashed lines denote dredged channels.

Lower panel: wind speed and direction at Eureka and tide at Site T7. The ticks on the tide curve denote the interval of the dye observations.

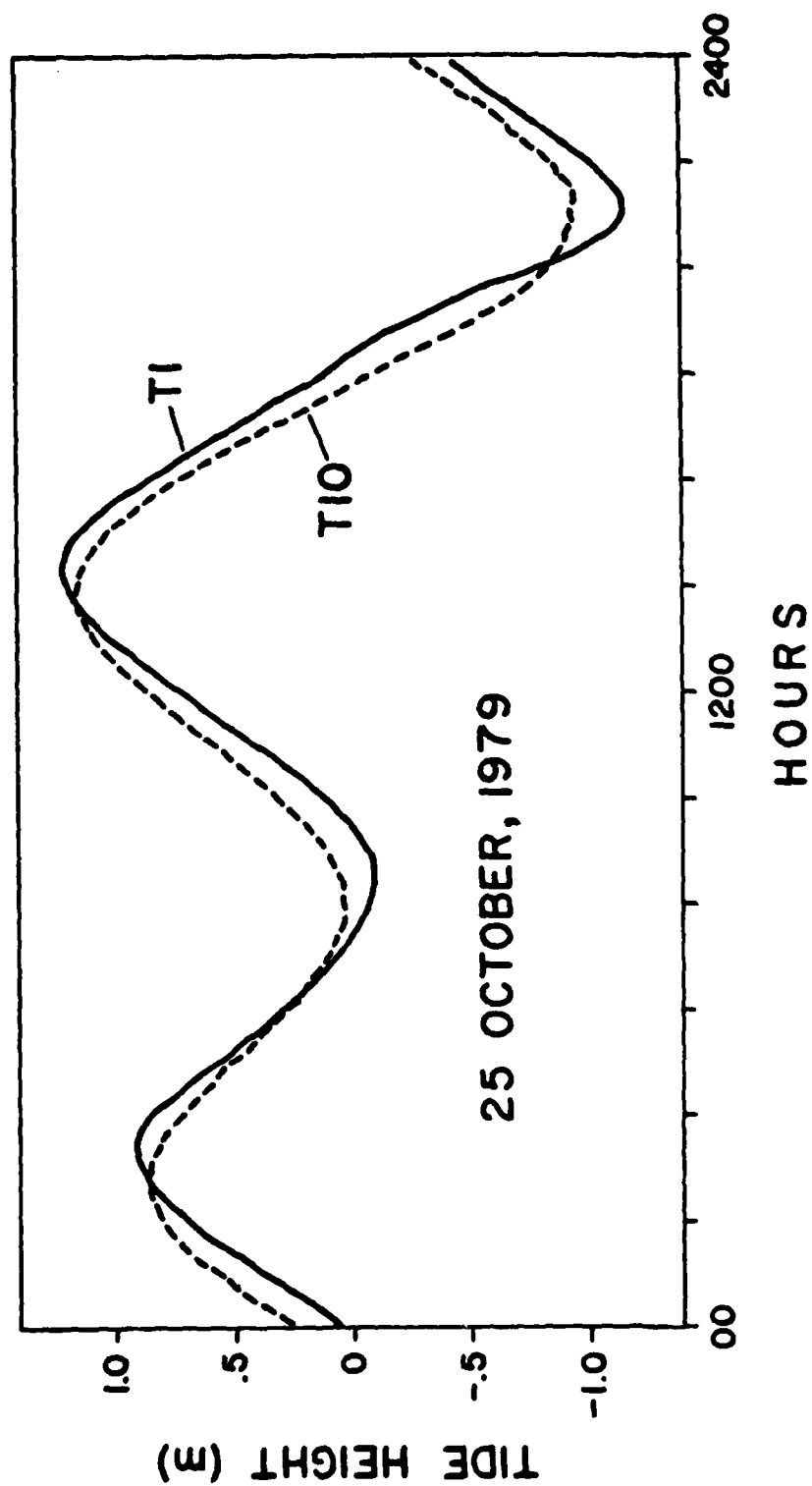


Figure VI-31f - Tides at Sites T1 (solid) and T10 (dashed) during 25 October 1979 (see Fig. 3 for locations).

Net water exchange between North and South Bays

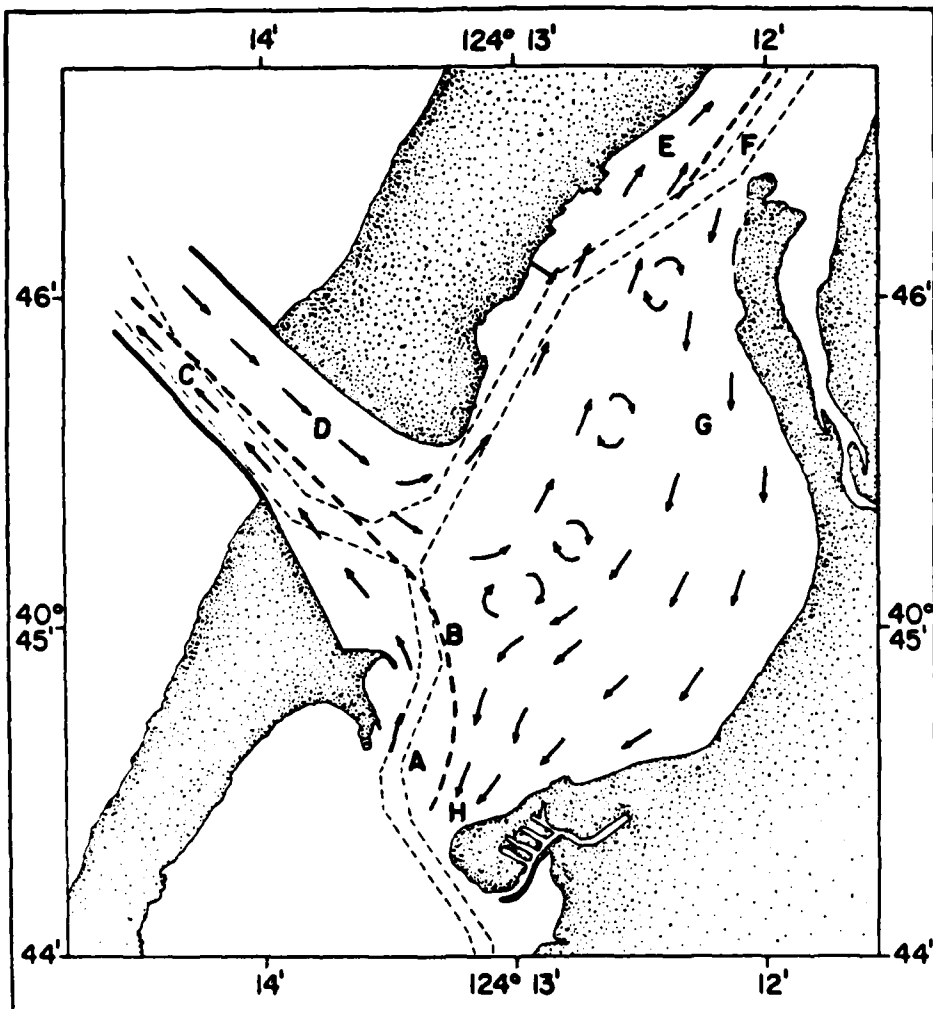
The tidal pumping mechanism described above induces a net circulation in at least Entrance Bay. Most likely there are also tidally pumped net transports in North and South Bays, but at present we are unable to resolve them. Our focus herein is primarily on Entrance Bay. Although numerous oceanographic studies have been conducted in Humboldt Bay, the tidal pumping mechanism presented herein has not been previously described.

Figure VI-31g shows a schematic of the net circulation in Entrance Bay and approaches as inferred from available historical data. Across the entrance to South Bay there are net countercurrents. The flow at Site A continues seaward through Entrance Channel at Site C where the National Ocean Survey tidal current tables show a net ebb current. As little freshwater enters the system, continuity must be maintained by a net inflow through Entrance Channel near Site D. Our hypothesis is that this landward flow continues into North Bay past Site E. The return flow at F from North Bay proceeds southward around Entrance Bay as typified at Site G and then into South Bay past Site H.

Flow of contaminants

From the results described in the preceding report, it is apparent that the movement of water between North and South Bays is a concern which should be addressed in more detail. The evidence so far suggests that North Bay water and any associated contaminants may be entering South Bay. Further study of the phenomenon may suggest the extent of this transfer and the potential impact on resources in South Bay.

Figure VI-31g



Schematic of hypothetical net circulation at surface in Entrance Bay induced by tidal pumping. Notation: A, net ebb flow from South Bay; B, horizontal divergence along rip line (dashed); C, net seaward flow in Entrance Channel continuing from South Bay; D, net landward flow in Entrance Channel; E, net landward flow continuing into North Bay; F, net southward flow from North Bay into Entrance Bay (G) and then into South Bay (H). The straight segment dashed lines indicate dredged channels.

J. BOTTOM SEDIMENTS

The deposition of sediment is common to all bays and estuaries. Deposition of sediment occurs in tidal channel bottoms and along their levees, and in tidal flats and salt marshes. Textural variations and the pattern of distribution of the surface sediments within the bay generally correlate with these morphologic units. The pattern of distribution also is related to the availability and source of sediment and the hydrologic character of the estuary. Modification and disruption of the estuary, such as dredging and oyster harvesting, can modify the pattern of sediment distribution.

In Humboldt Bay several studies have investigated sediment distribution and deposition (Thompson, 1971; Burdick, 1976; Boyd et al., 1975; and Moore, 1977. In addition, the reports of Brown, III (1975) and Ritter (1972) provided valuable data relating sediment in the Mad and Eel Rivers to the beaches of North and South Spits. These studies are the primary source of information for this section.

Sediment Distribution

A major result of Thompson's (1971) investigations was a generalized map of the distribution of various sediment types within the Bay. His data are presented on Plate 9. Thompson characterized the Bay floor into three morphologic units: tidal channels, tidal flats, and salt marshes. He noted that textural variations of surface sediments generally correlate with bay floor morphology. The textural range of sediments within the bay consist of sand, silty sand, sand-silt-clay, clayey silt, and silty clay. In general, the coarser sediments are deposited on the tidal channel floors and the finer sediments on the tidal flats and in salt marshes. The finer sediments of the tidal flats are subdivided into three groups: Very clayey silt and silty clay, moderately clayey silt, and slightly clayey silt. The morphologic units of the Bay and associated sediments are described below.

Tidal channels are the deepest parts of the Bay and are almost wholly below mean lower low water (MLLW). Depths of the channels in the upper reaches of Arcata and South Bay are on the order of 6 to 12 feet, but are up to 30 feet deep near the entrance. The channels shoal in an up bay direction where they form a complex tributary system and ultimately converge with the tidal flats. Sediment type within the tidal channels principally consists of sand, silty sand, and sand-silt-clay mixtures. The general distribution, although not uniform, is of decreasing particle size with the increasing distance from the bay entrance. The most obvious change is an increase in the percentage of silt and clay nearer the tidal flats.

Tidal flats comprise the nearly flat surfaces of the bay floor between the tidal channels and the bay margins. Tidal flats

The geological map displays the spatial distribution of various soil types within a study area. The map is oriented with North at the top. The soil types are labeled as follows:

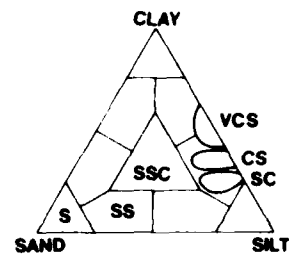
- VCS**: Very Clayey Sand
- SSC**: Silty Sand with Clay
- CS**: Clayey Sand
- S**: Sand
- M**: Medium Sand
- CLAY**: Clay
- SAND**: Sand
- SILTY SAND**: Silty Sand
- SILTY CLAY**: Silty Clay

The map shows a complex pattern of these soil types, with VCS and SSC being the most prevalent. The distribution is characterized by irregular, elongated shapes and boundaries, indicating a heterogeneous geological environment. The map is a black and white line drawing with text labels for each soil type and boundary lines separating the different soil units.

BOTTOM SEDIMENTS

PLATE NO 9 NORTH

LEGEND



M - MARSH



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: Thompson 1971

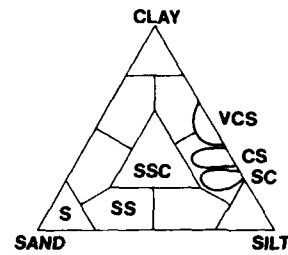




BOTTOM SEDIMENTS

PLATE NO 9 SOUTH

LEGEND



M - MARSH



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: Thompson 1971

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NOT FOR LEGAL USE

are the most extensive morphologic unit of the bay, occupying approximately 77% of Arcata Bay and 81% of the area of South Bay. Thompson (1971) further subdivided the tidal flats into the low and the high flats.

The low flats comprise the areas near or below MLLW, and in most locations are characterized by dense stands of eelgrass. Sediments are typically sandy textured in Arcata Bay, consisting of sand-silt-clay and silty sand, whereas in South Bay, surface sediments are predominantly slightly clayey silt (Thompson, 1971).

The high flats are located in the intertidal zone from the bay margin at an elevation of 4 to 5 feet (MLLW) to about the MLLW level. The high flats are generally muddy and barren of vegetation except for a seasonal mat of the algae *Chaetomorpha aerea* (Thompson, 1971) and *Enteromorpha* sp. and other algae (CNACC, 1978). Sediments of the high flats consist chiefly of very clayey silt and silty clay.

The transition zone between the high and low flats is marked by an irregular surface of barren mudmounds and small irregular depressions where eelgrass grows. Moderately clayey silt prevails in this zone and also covers extensive areas of the low flats.

Generally, surface sediments on the tidal flats correlate with bottom morphology where the high flats are generally finer grained than the low flats, and exhibit a fining up bay distribution. This general decrease in particle size with increasing elevation and distance away from the inlet is also noted in the tidal channels.

The uppermost morphologic unit within the bay is the salt marshes. Salt marshes are usually separated from the adjacent high tidal flat by a wave cut cliff, 2 to 3 feet in height, and once characterized by a dense growth of hydrophytic plants. The landward extent of the marshes along the bay margins has been largely eliminated by levees. Thompson (1971) estimated this loss at 85-90%. The sediments of the bay fringe salt marshes consist chiefly of silty clays and are finer grained than other bay morphologic units. Thus, the general trend of finer sediments with increasing distance and elevation from the entrance is completed.

The most important factor controlling sediment distribution is the tidal current system (Thompson, 1971). This assumed the primary source of sediment within Humboldt Bay is derived through the tidal inlet. Turbulence is generally too great in the lower reaches of the tidal channels for silt and clay to accumulate. Near the upper reaches of the tidal channels, velocities are too sluggish to transport sand, and therefore the finer predominate. Mixtures of mud and sand accumulate in the transition zone due to alternating tidal conditions. The remaining sand and silt in suspension is deposited along channel margins and low tidal flats due to wanning

tidal currents. The remaining winnowed fines are transported to the high flats and salt marshes where they are deposited due to slackening tidal currents.

Several exceptions to the general sediment distribution pattern have been noted by Thompson (1971). These include:

- . Sand and gravel sediments near the mouth of Jacoby Creek.
- . Moderately clayey silt (rather than silty clay) along east shore of North Bay.
- . The Sand Islands in North Bay.
- . Sand ridges along the east side of South Spit.

Jacoby Creek has built a small distributory delta on the tidal flats in the northeast corner of Arcata Bay. The sediments consist of silty sand with some gravel. Interbedded silty sand and clayey silt predominate out to a distance of 1500 feet from the mouth of Jacoby Creek (Thompson 1971). These coarse outwash sediments on the high flats are clearly a result of winter runoff from Jacoby Creek. Northwesterly winds and full fetch create larger than normal waves along the east shore of Arcata Bay. This results in coarse sediment accumulation and winnowing of finer sediments. Accelerated erosion of the salt marsh here has also been attributed to increased wave action. Sand Islands were apparently formed from dredge spoils from the Arcata Channel. The channel was dredged between 1911 and 1920 to improve access to the Arcata Wharf (University of Washington, 1955). The sand waves or megaripples along the east side of South Spit are apparently derived from reworked beach and dune sand, and overwash deposits resulting from winter storms. These sand ridges have been observed to migrate northward as a result of wave and tidal currents (Cook, 1970).

Thompson (1971) has also noted significant differences in the distribution of tidal flat sediments of North and South Bays. In general, a greater proportionate area of North Bay is covered by very fine sediments (silty clays and very clayey silts) than in South Bay. Thompson attributes the generally finer sediments in North Bay to a variety of factors that have resulted in greater accretion and infilling of North Bay. These include:

- . A greater proportionate area of high flats, that tend to accumulate the finer sediments.
- . Greater direct sediment input from upland runoff.

- . A significantly slower rate of tidal flushing* that enhances a more rapid net accretion.
- . Extensive dredging and oyster harvesting that stirs bottom muds into suspension.
- . North Bay may be older, and therefore may have been protected from the oceanic energy regime for a longer time.

In contrast, the low flats of South Bay are covered with finer sediments than the low flats of North Bay. Thompson (1971) indicates that oyster harvesting is the principal factor in these textural differences. Commercial oyster harvesting on the low flats of North Bay stirs up the substrate, allowing fine sediments to be preferentially removed. Coarse shell material is added to the flats as a part of the growing process. Also, extensive stands of eelgrass in South Bay may slow current action and also trap fine sediments. Oyster harvesting significantly reduces such stands in North Bay.

A variety of base information indicate that certain areas within Humboldt Bay are presently undergoing active erosion and accretion. Certainly some of these processes can be directly attributed to human modification of the natural system. Construction of jetties and dredging of the bay entrance channel have been correlated to concentrated tidal currents that have resulted in the erosion of Buhne Point and the accretion of Elk River Spit. Other areas that are undergoing active erosion are the salt marshes along the bay margins and on Indian Island. Thompson (1971) indicates that marsh retreat between North Point and Eureka Slough occurred at an average rate of 2 to 4 feet per year from 1911 and 1966 and is attributed primarily to wave action. However, the marshes adjacent to McDaniel Slough and Jacoby Creek show no erosion for the same time period. This is probably due to the protection from significant wave action in the McDaniel Slough area and the high sediment yield from Jacoby Creek. The sediment of Jacoby Creek is actively building an outwash fan on the high flats in this area. In South Bay, the northward migration of the sand waves has resulted in sediment accumulation to form an east trending recurved spit on the bayward side of South Jetty. This sediment may also contribute to the shoaling of Fields Landing Channel and the shoal that exists across the north end of Southport Channel.

*See Section VI-1. Currents And Circulation, for a discussion of tidal flushing.

Sediment Sources

The origin and type of sediment in Humboldt Bay may vary considerably, but three primary sources have been identified: direct input from upland water runoff (river discharge), inflow through tidal inlet (shore erosion, rivers, and ocean bottom) and biological activity. Aeolian or overwash sediments from adjacent spits may also be an important source. Unfortunately, there has been little study to determine the relative contribution of each of these sources to the total sediment within Humboldt Bay. Thompson (1971) has estimated the amounts of sediments entering the bay from various sources (Table VI-7). These are rough estimates based in part on quantitative data and in part on detailed assumptions.

Table VI- 7

SEDIMENT SOURCES IN HUMBOLDT BAY

<u>Source</u>	<u>Import</u> <u>(x10³m³/yr)</u>	<u>Export</u> <u>(x10³m³/yr)</u>
Upland runoff from rivers and creeks (Thompson, 1971)	90	
Import from the ocean (Thompson, 1971)	540-670	
Dredging (Corps, 1963; Thompson, 1971)		510

The net result is an annual input of $120-250 \times 10^3 \text{ m}^3$ of sediment, assuming a sedimentation rate within the Bay at 0.2-0.4 cm/year.

The above sediment budget is based on conditions as they were in 1971. Most recent data show the Corps removes approximately $620 \times 10^3 \text{ m}^3$ of sediment per year from Humboldt Bay (Corps, 1976(2)). This increase may result in part from the increased width and depth of channels being dredged.

It should be noted that only the figures on dredged material were actually measured. The upland runoff volumes were estimated based on the mean annual water discharge of Jacoby Creek and Elk River, and an assumed sediment concentration. The ocean import volume is calculated from the dredged value, upland input volume, and an assumed annual rate of deposition (Thompson, 1971). Thompson has also noted that overflow from the Mad River into Mad River Slough

may contribute to sediments to the Bay, although no estimate of this contribution is available.

Although no study of organic sediments in Humboldt Bay has been undertaken, Boyd et al. (1975) did determine the amount of biogenous material in samples taken from Entrance Bay. The material constituted from 0 to 35% of his samples. In general, these samples were predominantly sand or gravel, and the biogenous material was shell fragments.

In addition to shell fragments, plant material is also a source of organic sediments in the Bay, especially in the marshes and on the tidal flats. Thompson (1971) noted organic concentrations as high as 70-80% in marsh sediments. This material is generated either in the marshes or in upland areas. That material which is not immediately added to the Bay is often buried and compressed, forming peat deposits. Organic material which is released from the wetlands is either consumed, transported to the ocean, or deposited in the Bay. Algal mats on tidal flats may also contribute to organic concentrations within the sediments through decay and burial.

Human activities also add sediments to the estuary. Wood fragments from timber industry operations are probably common in some sediments. Riprap, sand, and other construction materials used in levees, bulkheads, and other structures may also become estuary sediments. Shell fragments are frequently added to tidal flats as part of oyster culturing.

On the ocean beaches, sediments are attributed primarily to one of two sources: river discharge of suspended sediment, and headland erosion. The Eel River has one of the highest sediment yields per unit area in the world and the volume of suspended sediment is at least 11 times greater than that of the Mad River (Ritter, 1972). During periods of high river discharge, the suspended sediment in the nearshore zone from this source far exceeds that of other sources. The supply of sand for the North and South Spits is probably derived from the Eel, Mad, and Little Rivers, and deposited by a combination of littoral drift and wave action. Differences in mean grain size and heavy-mineral percentages of sand samples from North and South Spits indicate that those sediments on South Spit may have been derived from the Eel River and those of the North Spit may have been derived from the Mad and Little Rivers (Ritter, 1972). Winter suspended sediment plumes observed from ERTS MSS imagery indicate that turbid water most likely from the Eel River is carried northward to the South Spit and into the Entrance Channel at flood tides (Carlson, 1976). This is due to the northerly flowing Davidson Current that occurs as a result of seasonal reversal in wind direction. During most of the year the California Current flows southerly and could account for Mad and Little River derived sediments on North Spit.

Summary

Sediment distribution within the Bay correlates well with bottom morphology and appears to be controlled predominantly by tidal currents. Sediment grain size generally decreases with increased distance from the inlet and increased elevation. The coarse sediment occurring in the channel bottoms and the fines in the high flats and salt marshes, as a function of wanning tidal current velocity in an up bay direction.

In general, North Bay is covered by finer sediments than South Bay, except on the low flats where the reverse is true. Several factors probably contribute to this, including dredging and oyster harvest activities in North Bay and a significant difference in tidal flushing between North and South Bays.

Sediments in Humboldt Bay come from a variety of sources. Input through the inlet appears to be the single greatest source, although Elk River and several small creeks probably contribute a discernible amount. In the marshes, organic material may constitute as much as 70% of the sediment.

K. WATER QUALITY

Although sediment deposition is affected relatively little by the freshwater sources, the streams discharging to the bay can be strongly influential in the water quality of the bay. These streams carry materials into Humboldt Bay from a variety of sources. The lowlands surrounding Humboldt Bay are heavily utilized as pastureland by both dairy and beef cattle; there are eight sewage treatment plants discharging into the bay; some residential development in the vicinity of the bay is non-sewered and may indirectly discharge into the bay; groundwater may also discharge into certain areas of the bay. Further, the tidal activity of the bay can also influence water quality.

Studies defining the chemical quality of Humboldt Bay are relatively sparse. Nutrients were studied by Skeesick (1963) and Gast and Skeesick (1964). Recently, nutrient studies have been conducted to evaluate wastewater treatment in the area (Metcalf and Eddy, 1979). It should be noted that the data of Skeesick (1963) and Gast and Skeesick (1964) were collected during the highest tide of each month; as a result, they represent conditions under maximum oceanic intrusion, and not necessarily mean conditions. The more recent data were collected biweekly at both high and low tides (Metcalf and Eddy, 1979).

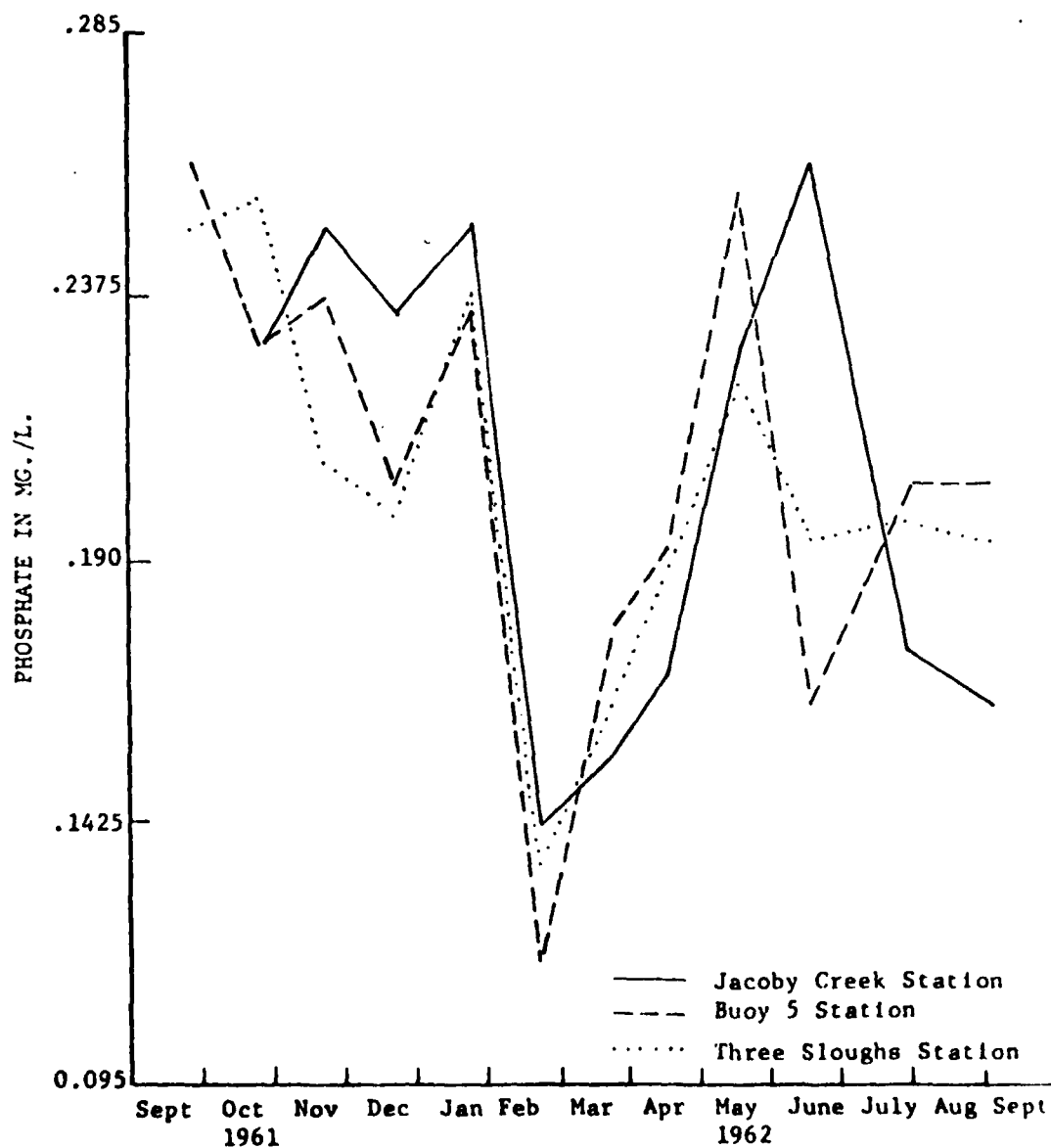
Gast and Skeesick (1964) found that both phosphate and silicate varied seasonally with the highest concentrations during the fall and winter, a decrease in February/March and a sharp decrease in August/September (Figures VI-32, 33). Although not stated in their reports, these fluctuations can probably be attributed to two phenomena. Between February and May, the increase in phosphate and silicate is due to the input of oceanic water through the upwelling; between May and September, the fluctuations may be attributable to phytoplankton, particularly diatom production.

Metcalf and Eddy (1979) report phosphate concentration for only two days in July 1979. Low tide phosphate concentrations were consistently greater than high tide concentrations, and also significantly greater than high tide concentrations reported by Gast and Skeesick (1964) for similar stations. High tide concentrations for similar stations were significantly lower than those of Gast and Skeesick (1964) on one day and approximately equivalent on the other.

Considerable emphasis was placed on nitrate concentrations within the bay in the Metcalf and Eddy (1979) study. Nutrient concentrations published in that study exhibit diverse characteristics. On 9 July 1979, offshore nitrate levels were considerably higher at low tide than at high tide (90-200 $\mu\text{g/l}$ versus 55-99 $\mu\text{g/l}$). On 23 July 1979, the reverse was true (750-780 $\mu\text{g/l}$ at low tide; 1,140-1,051 $\mu\text{g/l}$ at high tide). In general, low tide nitrate concentrations tended to be lower than high tide concentrations within the bay, but the variation was most apparent between the two days sampled at either high or low tide. (Table VI-8 shows data reported for 9, 23 July 1979.)

Figure VI-32

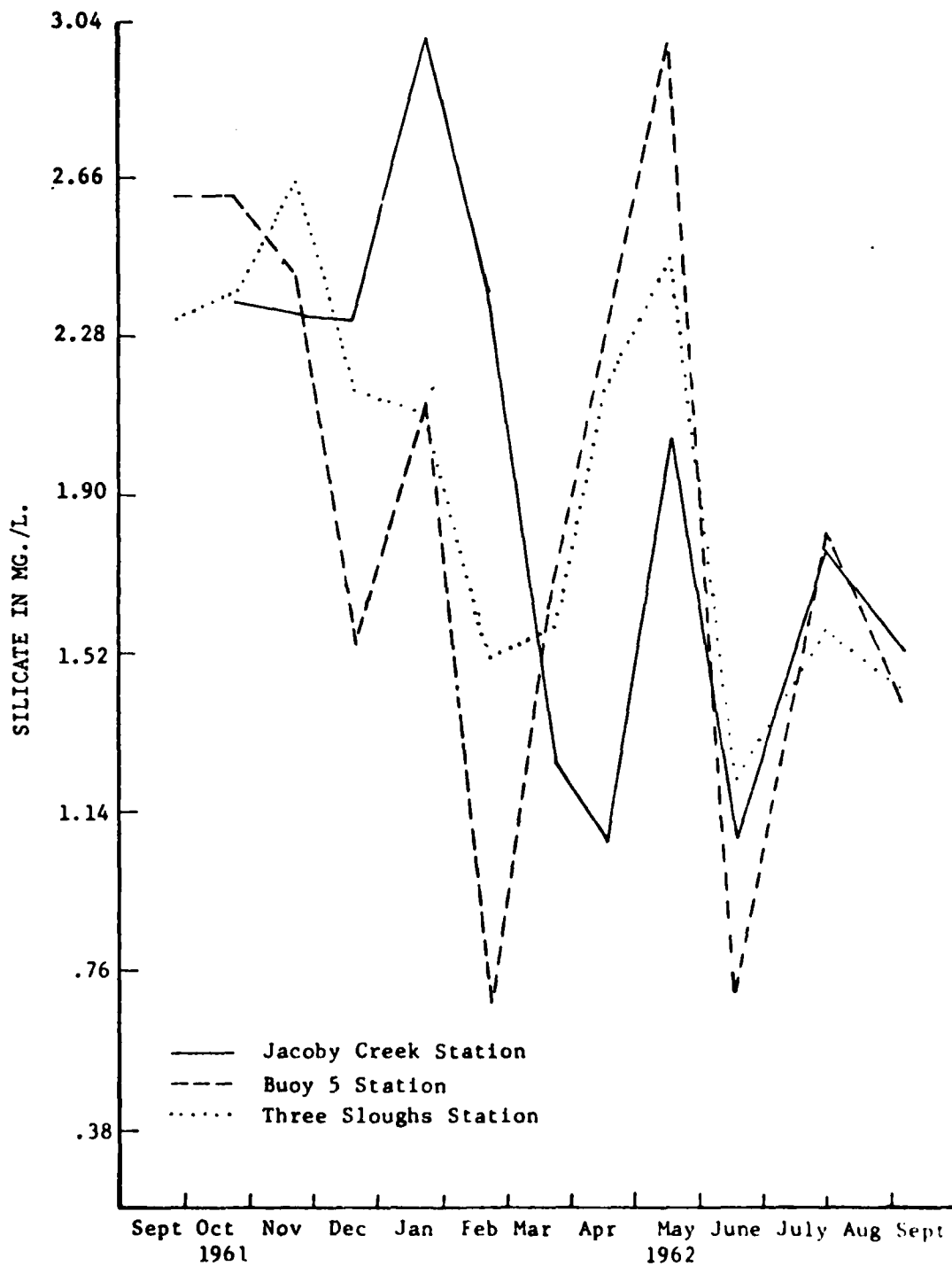
AVERAGED PHOSPHATE VALUES AT THREE STATIONS IN HUMBOLDT BAY. After Gast and Skeesick (1964).



Source: ERC, 1974

Figure VI- 33

AVERAGED SILICATE VALUES AT THREE STATIONS IN HUMBOLDT BAY.
After Gast and Skeesick (1964).



Source: ERC, 1974

Table VI-8

NUTRIENT CONCENTRATIONS (μ gram-atom) FOR HIGH
AND LOW TIDE FROM SEVEN STATIONS IN HUMBOLDT BAY
(after Metcalf and Eddy, 1979)

Date	Location	Depth, m	Nutrient Data -- μ g-atom/liter					
			Low Tide			High Tide		
			PO ₄	NO ₃	NH ₄ ⁺	PO ₄	NO ₃	NH ₄ ⁺
9 July 1979								
	HB-1	Surface	0.96	1.46	0.68	0.40	0.89	0.00
		5	0.19	3.25	0.31	0.24	1.60	0.12
	SB-1	3	2.75	1.34	1.24	0.33	0.31	0.25
	SB-2	2	3.77	0.72	1.12	0.73	0.78	0.93
	CH-1	3	2.48	0.15	1.43	0.46	2.72	0.36
	CH-2	3	2.76	1.74	1.80	0.36	0.97	0.25
	NB-1	3	2.30	0.78	1.67	1.12	2.81	0.43
	NB-2	2	5.00	0.59	3.35	1.81	1.08	3.22
23 July 1979								
	HB-1	Surface	1.53	12.14	2.36	1.55	18.33	0.87
		5	1.70	12.57	0.56	1.32	16.96	3.02
	SB-1	3	2.58	3.04	3.91	1.64	18.76	3.84
	SB-2	2	3.18	3.22	2.23	1.85	11.07	1.67
	CH-1	3	2.80	4.67	4.03	2.01	19.63	2.48
	CH-2	3	3.56	4.84	3.78	2.17	14.07	2.67
	NB-1	3	3.27	2.47	7.13	1.76	20.47	1.49
	NB-2	2	5.93	3.00	3.60	2.77	2.29	3.78

To convert PO₄ μ g-atom/liter to mg/liter, multiply by 0.095

NO₃ μ g-atom/liter to mg/liter, multiply by 0.062

NH₄⁺ μ g-atom/liter to mg/liter, multiply by 0.017

Station Locations:

- HB-1 - Approximately one mile west of Bay mouth
- SB-1,2 - South Bay
- CH-1,2 - Entrance Bay
- NB-1,2 - North Bay

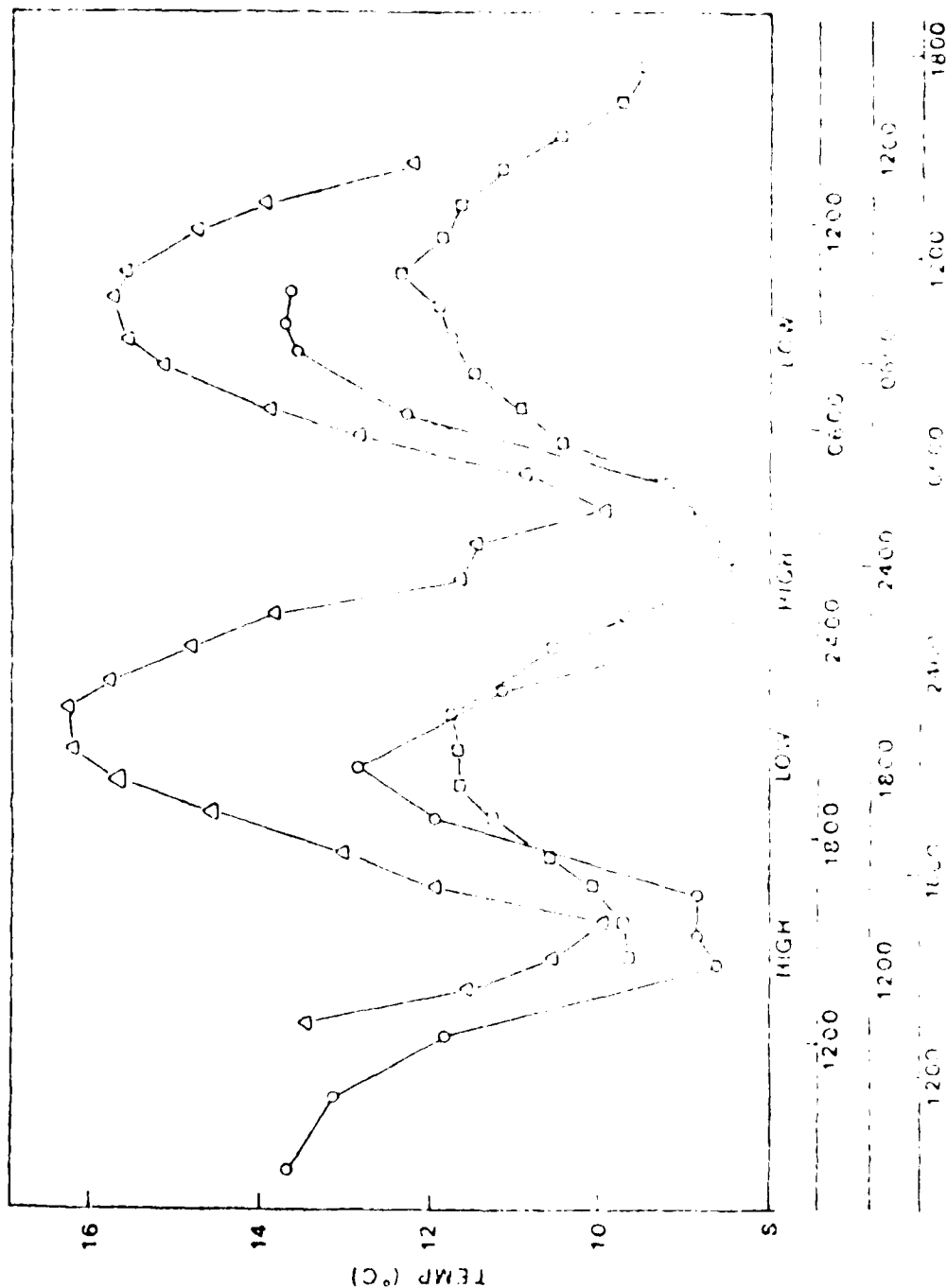
Dissolved oxygen generally appears to be related to the concentrations found in the incoming inlet water and the mixing processes as the water moves throughout the bay. The highest (11.97 $\mu\text{g/l}$) and lowest (4.26 $\mu\text{g/l}$) values were recorded (between September 1961 and September 1962) at the entrance; the most stable values were found in the northeast quadrant of Arcata Bay (ranging between 8 and 9.6 $\mu\text{g/l}$ annually) (Gast and Skeesick, 1964). The results of Metcalf and Eddy (1979) generally show a decrease in DO from the bay mouth to upper North Bay, except in June and July, where high tide DO appears higher between approximately mile 4 and mile 6 (Fairhaven to Samoa Bridge). Davidson (1977) found dissolved oxygen varied through the tidal cycles; no consistent pattern was observed, however.

Temperature is closely related to distance from the mouth of the bay. On an annual basis, temperatures are the least variable near the entrance and most variable in the shallow flats of Arcata and South Bays. The variability is attributable to the changes in mean monthly air temperatures (Skeesick, 1963; Gast and Skeesick, 1964). Metcalf and Eddy (1979) showed little or no temperature stratification at either high or low tide during summer sampling.

Salinity varies greatly within the bay and is dependent upon runoff and precipitation. Characteristically, the salinity is higher during the summer and decreases during the fall and winter, coincident with the increase in rainfall. Evaporation may also play a role in salinity variation. Skeesick (1963), Bonnet (1936) and Davidson (1977) suggested that during June and July salinity increased, although they did not indicate the magnitude of that increase. Salinities decrease during periods of high rainfall and runoff. Beittel (1975), sampling during low and high tide, found significant variations. He postulated that North Bay is composed of two water compartments, that of nearshore oceanic water that fills the channels at high tide, and that of bay water that occupies the channels at low tide. He concluded that little mixing between the two occurs.

Davidson (1977) conducted a study through the spring and summer of 1977 to determine the influence of tides upon water quality variability. His results demonstrated variability within tidal cycles with little variability among depths. Temperature and salinity varied markedly throughout the tidal cycle (Figures VI-34, 35). The highest temperature and lowest salinity were observed at low slack water.

Temperature and salinity also changed seasonally. Spring-time temperatures ranged between 8.26°C and 13.72°C. Summer water temperatures varied the greatest (between 9.97°C and 16.26°C); spring-time salinities ranged between 32.92‰ and 33.86‰. The smallest variations in salinity occurred during the summer with ranges of less than 0.31‰ (33.32‰ to 33.63‰).

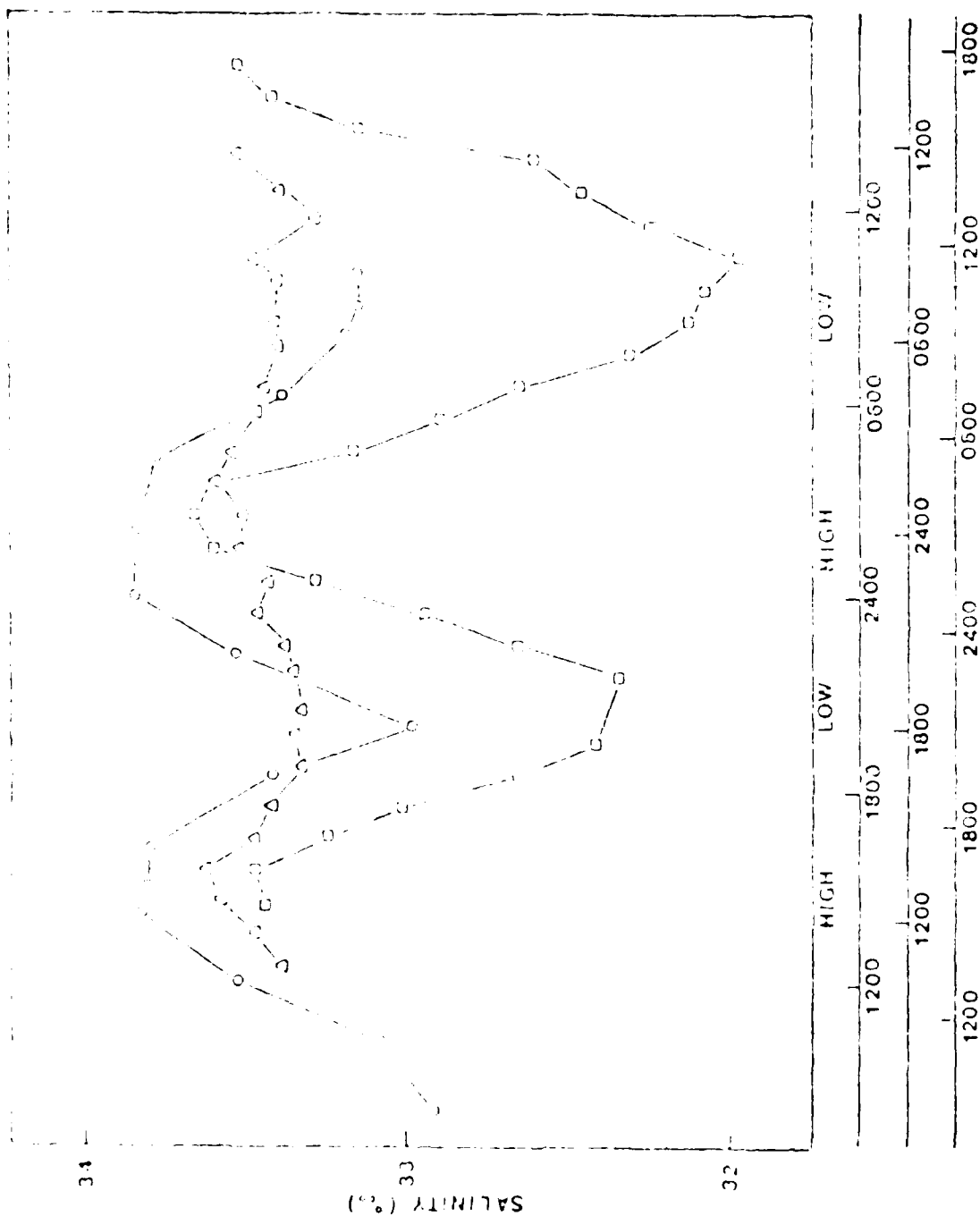


Source: Davilson, 1977

TEMPERATURE THROUGHOUT A TIDAL CYCLE

The top time scale refers to the spring of 1976 (circles); the middle scale refers to the summer of 1976 (triangles); and the lower scale refers to the spring of 1977 (squares).

Figure VI-34



Source: Davidson, 1977

The top time scale refers to the spring of 1976 (circles); the middle scale refers to the summer of 1976 (triangles); and the lower scale refers to the spring of 1977 (square).

Figure VI-35

Nutrients (measured only in the spring) were affected by tidal stage. Nitrate concentrations were highest during high tide. During the spring of 1976, they ranged between 0.1 and 1.1 mg/l and during the 1977 spring, the range was 0.6 to 0.9 mg/l. Phosphate showed the lowest concentrations (0.15 to 0.11 mg/l) during high tide.

The concentrations of chlorophyll a varied throughout a tidal cycle, and striking differences occurred among the three sampling periods. In the spring of 1976, the greatest variations with the tide were noted; the concentration varied from 3.3 mg/m³ at high tide to 11.0 mg/m³ at low tide. In the summer, the concentration varied from 0.1 to 4.1 mg/m³ with the lowest values occurring at or near low water. The following spring (1977), the concentrations varied 0.9 to 2.1 mg/m³ with the minimums at low water.

Temperature and salinity values observed at high and low tide indicate neritic and bay conditions, respectively. At high tide, it was evident that nearshore oceanic water was being sampled because of colder temperatures and higher salinities. These results varied among sampling periods in accordance with changes in upwelling. It was found that the coldest and saltiest waters occurred at high tide when the upwelling was greatest. Furthermore, the high tide values of temperatures and salinity corresponded with the relative degree of upwelling. This illustrates that water within the channels of the bay at high tide is influenced by the nearshore oceanic environment.

Davidson (1977) further concluded that his results verified Beittel's (1975) in that there are two water compartments in the bay--that which is retained in the bay and that which is exchanged with the ocean. This appears to conflict with the results of model studies done as part of this project (see Circulation and Currents, Sec-VI.I).

The water within the bay is affected by both the bay and nearshore ocean water. Oceanic upwelling results in import of silicate and phosphate nutrients and bay processes tend to retain the phosphate. Chlorophyll and dissolved oxygen variability suggest that the bay's biota is influenced by both nutrients and is not dominated by only one.

Water quality standards and objectives have not been promulgated for nutrients. The objectives and standards for temperature, dissolved oxygen and coliform bacteria were developed in 1967 and revised in 1975 (State Water Resources Board, 1975).

Temperature standards basically require that temperature not be significantly over ambient nor altered to a degree which creates an adverse impact upon aquatic life. The discharge of PG&E's Humboldt Power Plant increases surface water temperature about 6.7°C over approximately one acre; however, no adverse effects have been detected (PG&E, 1973).

The objective for dissolved oxygen for Humboldt Bay was established at 7.0 mg/l on an average annual basis with no values allowed below 6.0 mg/l (State Water Resources Board, 1975, pg 1-3-3). As indicated above, dissolved oxygen concentrations less than 5.0 mg/l have been reported. This is apparently due to the upwelling of oxygen deficient deep ocean waters. Gast and Skeesick (1964) noted relatively lower water temperatures and dissolved oxygen concentrations which they attributed to upwelling during December and January, and April and May (Figure VI-36). It appears to be a natural phenomena and not a violation of standards.

The bacterial component of Humboldt Bay water quality is well studied because of the commercial harvest of oysters. National Shellfish Sanitation Program (NSSP) standards apply in areas where shellfish are harvested for human consumption. The standards for growing waters are that the total coliform bacteria median most probable number (MPN) shall not exceed 70 per 100 ml and not more than 10% of the samples shall exceed a MPN of 33 per 100 ml. Fecal coliform shall not exceed 14 MPN. The standard for oyster meat is a sample 35°C Standard Plate Count limit of 500,000 per gram, total coliform of 16,000 MPN and fecal coliform of 230 MPN. Because coliform bacteria are present in the gut and, therefore, the feces of all warm-blooded animals, the coliform test can only be used as an indicator of the presence of human fecal material that may or may not carry harmful pathogens such as hepatitis or dysentery.

Sources of coliform bacteria to Humboldt Bay are from point source and non-point source discharge. Point source discharge to the bay occurs when there is a wastewater treatment plant power failure, when inadequate chlorination occurs because of equipment malfunction, or when the inflow of water during intense storm runoff exceeds the physical capacity of the plant to properly chlorinate infiltration water.

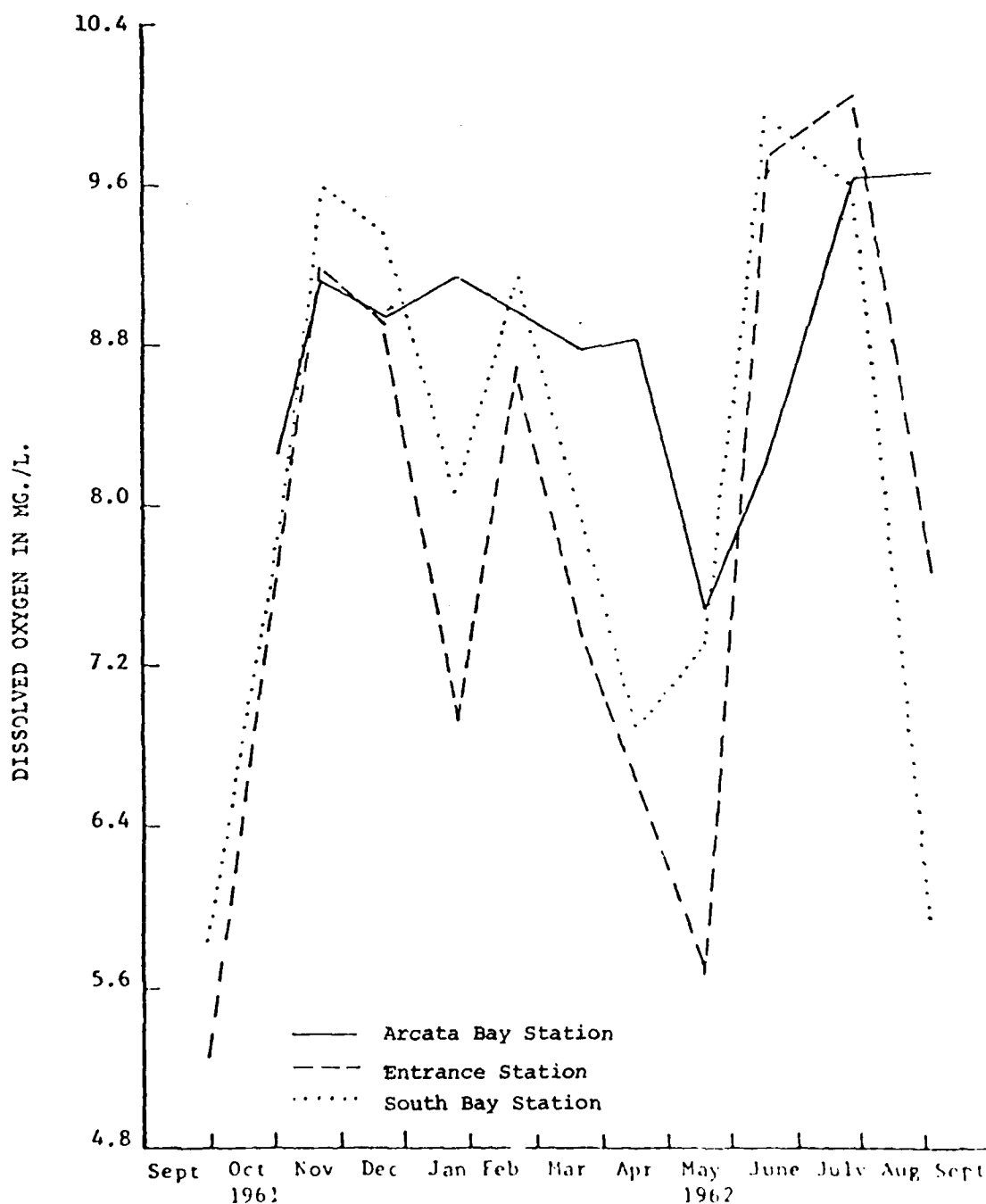
Some of the existing wastewater treatment plants are at infiltration capacity even in dry weather. Non-point source discharge to the bay occurs as a result of runoff from adjacent agricultural land and from failing septic tanks in unsewered areas.

In 1974, the California State Public Health Department issued a policy of a commercial shellfish harvest closure for five days following 0.5 inches of rainfall in any 24 hour period. Studies indicate that oysters are purged of almost all traces of coliform bacteria after this time and return to standards (California Department of Health, 1973 and 1974; FDA, 1978). Winter is the primary oyster harvest season as gonadal development is at a minimum. Severe storms in succession can close the shellfish beds to commercial harvest for many weeks.

An agreement exists between all responsible entities in accordance with the Northcoast Regional Water Quality Control Board

Figure VI-36

AVERAGED DISSOLVED OXYGEN AT THREE STATIONS IN
HUMBOLDT BAY (after Gast and Skeesick, 1964)



Order No. 74-19, which states that if an accidental bypass results in a point source discharge, the shellfish growers and the State Department of Health are notified immediately. State Health places a moratorium on all shellfish harvest until the nature and extent of the bacterial contamination is determined and coliform levels return to standards.

Several wastewater treatment systems and plant upgrades have been proposed for improved collection and treatment of wastewater from urban and rural centers surrounding the bay. A regional secondary wastewater treatment system with ocean discharge was proposed by the Humboldt Bay Wastewater Authority. A marsh wastewater treatment system upgrade is being constructed in the City of Arcata. The City of Eureka has proposed a secondary treatment plant with marsh or bay discharge.

Most smaller communities in the Humboldt Bay watershed are not sewered. The high capital and operating costs associated with traditional mechanisms of wastewater treatment is prompting small communities to investigate alternative systems such as septic tank maintenance districts and community septic tanks. Poor soil structure may prohibit the use of septic tanks in many of these areas. Coliform bacterial additions to the bay will continue from non-point source agricultural land runoff even after improved capacity wastewater treatment plant and properly maintained septic tanks are operational, although human pathogen transfer is less likely to occur from agricultural land runoff.

L. HABITAT TYPES

It is important to distinguish between habitats, as defined in a classic ecological sense, and the habitat types described here. Habitat is defined as the place where an organism normally lives. Habitat type refers to a specific vegetation association classified and mapped in Volume 3 of the Humboldt Bay Wetlands Study and Baylands Analysis.

A habitat may be described in several different ways. In the case of a plant, habitat is often defined as a specific set of physical characteristics and, sometimes, associated plants. In the case of a terrestrial animal, habitat may be defined as a variety of plant communities (some with similar physical characteristics) or a variety of physical characteristics (some with similar plant communities).

A habitat type, on the other hand, is a plant community or plant association. Occasionally physical characteristics may be used to distinguish certain habitat types with similar plant associations (such as tidal versus non-tidal freshwater wetlands). In some parts of the study area habitat types are classified according to activity (urban) or physical characteristics (water). However, the plant community is the primary delineation of habitat type used in this discussion.

In the Humboldt Bay region nine major habitat types have been identified and mapped. These include:

- . Urban
- . Agriculture
- . Grassland
- . Shrubland
- . Forest
- . Water
- . Wetland
- . Dunes
- . Jetties and Reefs

Each of these habitat types is described in this profile and its distribution mapped on Plate 10. The area of each habitat type according to subarea is listed in Table VI- 9. Several of these habitat types have been divided into sub-types according to specific characteristics; these sub-types are mapped at a scale of 1:6000 (see Volume 3 of this study).

Urban areas are comprised of residential and industrial habitat types that are usually found in areas of dense human habitation. These include transportation facilities, port and harbor structures, mines and gravel pits, and open areas which have been scraped or filled but are not otherwise being used. Generally, urban areas support little wildlife since the vegetation is often sparse, exotic (non-native), and managed for aesthetic rather than wildlife

HABITAT TYPES 1978

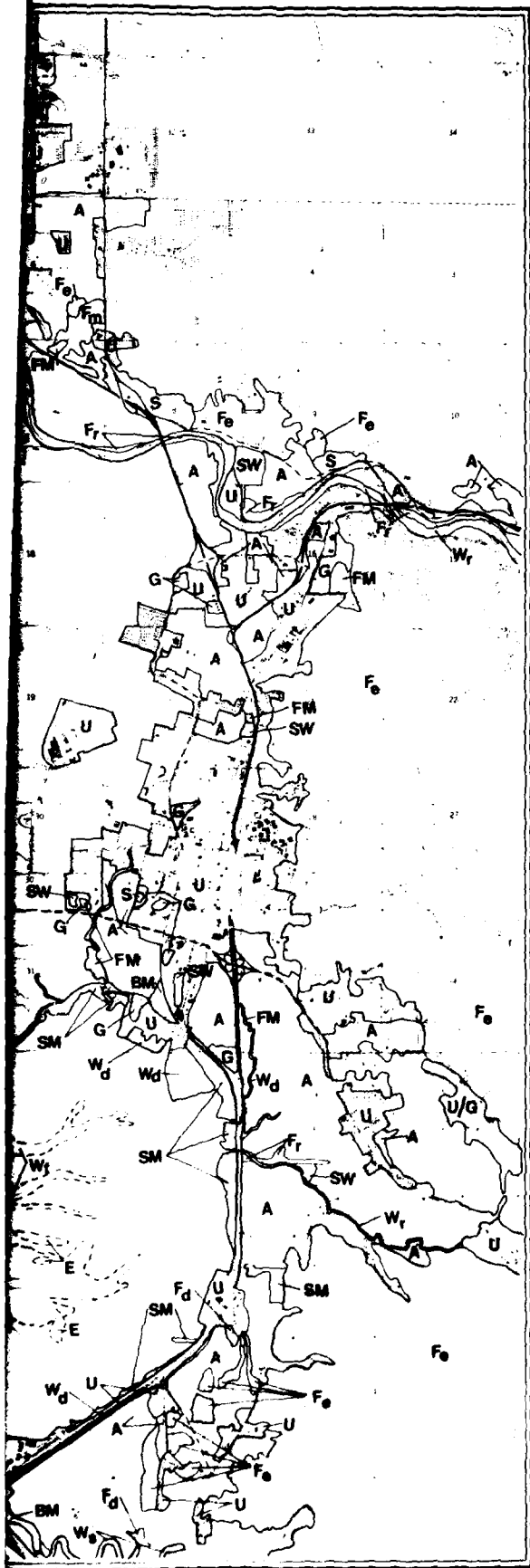
PLATE NO 10 NORTH

LEGEND

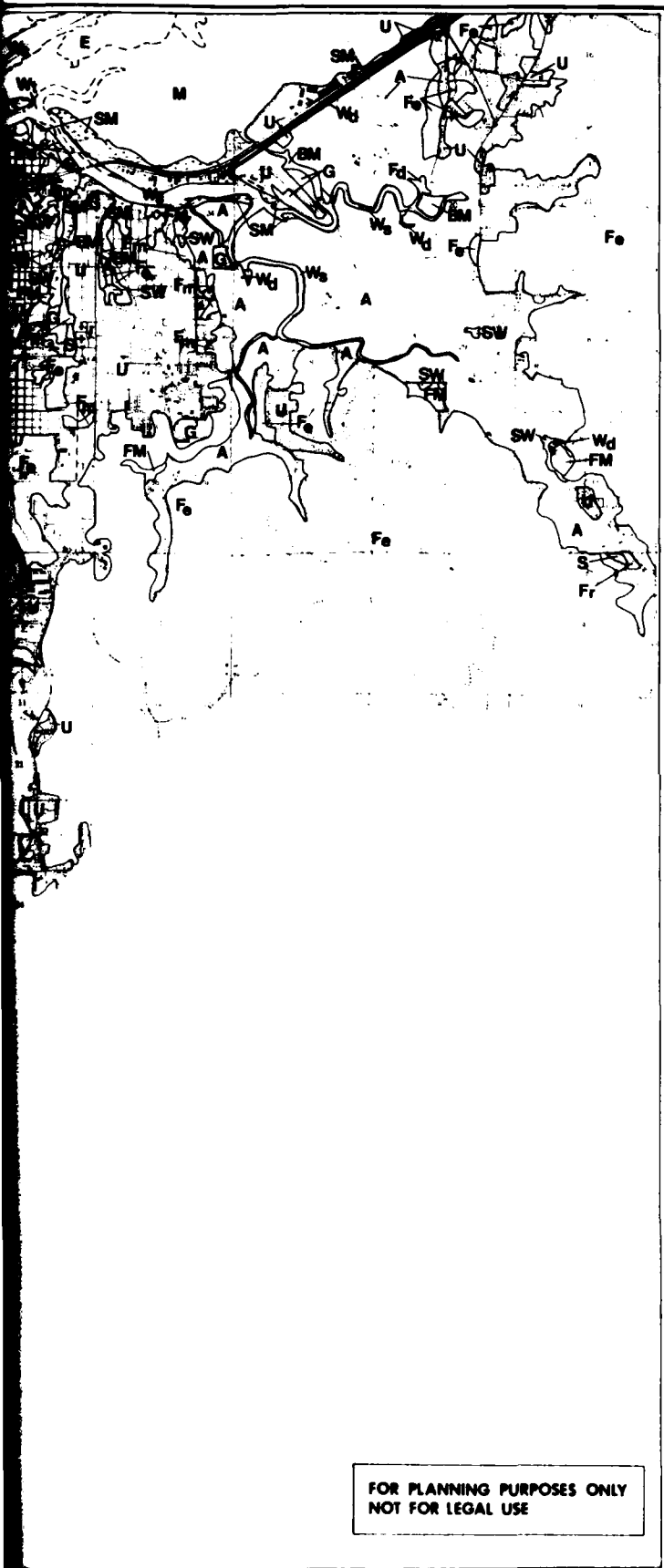
- | | |
|-------------------------------------------------------------------------------------------------------|-----------------------------|
| A | Agriculture |
| B | Beach |
| Dh | Dune Hollow |
| Dm | Moving Dune |
| Da | Dune Swamp |
| Dsp | Sparsely Vegetated Dune |
| Dv | Vegetated Dune |
| Fd | Deciduous Forest |
| Fe | Evergreen Forest |
| Fm | Mixed Forest |
| Fp | Pine Forest |
| Fr | Riparian Forest |
| G | Grassland |
| J | Jetties and Reefs |
| S | Shrub |
| U | Urban |
| Wetlands | |
| SM | Salt Marsh |
| BM | Brackish Marsh |
| FM | Freshwater Marsh |
| SW | Swamp |
| E | Eelgrass |
| M | Intertidal Flat |
| Wc | Deep Tidal Channels |
| Wd | Ditches and Closed Channels |
| Wr | Creeks and Rivers |
| Ws | Tidal Creeks and Sloughs |
| Wt | Shallow Tidal Channel |
| * As interpreted from Dec 1978 aerial photos
** Upstream limits of tidal influence are approximate | |



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS







HABITAT TYPES 1978

PLATE NO 10 SOUTH

LEGEND

- A Agriculture
- B Beach
- Dh Dune Hollow
- Dm Moving Dune
- Ds Dune Swamp
- Dsp Sparsely Vegetated Dune
- Dv Vegetated Dune
- Fd Deciduous Forest
- Fe Evergreen Forest
- Fm Mixed Forest
- Fp Pine Forest
- Fr Riparian Forest
- G Grassland
- J Jetties & Reefs
- S Shrub
- U Urban
- Wetlands
 - SM Salt Marsh
 - BM Brackish Marsh
 - FM Freshwater Marsh
 - SW Swamp
 - E Eelgrass
 - M Mudflat
 - Wc Deep Tidal Channels
 - Wd Ditches & Closed Channels
 - Wr Creeks & Rivers
 - Ws Tidal Creeks & Sloughs
 - Wt Shallow Tidal Channels

• As interpreted from Dec 1978 aerial photos
 •• Upstream limits of tidal influence are approximate



HUMBOLDT BAY WETLANDS REVIEW
 &
 BAYLANDS ANALYSIS

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 NOT FOR LEGAL USE

Table VI-9

Areal Extent of Habitat Types by Subarea¹ (acres)

Subarea ³	Habitat Types ²														TOTAL
	Agriculture	Beach	Dunes	Forest	Grassland	Jetties	Shrub	Urban	Salt Marsh	Brackish Marsh	Fresh Marsh	Swamp	Intertidal Flat	Water	
Beatrice Flats	1,626	-	-	32	4	-	32	105	125	36	-	6	43	96	2,111
Table Bluff	546	-	-	121	-	-	30	38	-	-	6	3	-	-	744
South Spit	120	199	568	-	-	9	-	35	20	-	1	2	-	5	959
Elk River	1,691	-	121	1,138	206	2	84	1,845	37	87	57	45	31	100	5,444
Eureka	7	-	1	160	107	-	29	2,340	23	37	25	38	1	1	2,769
Eureka Slough	2,140	-	-	659	97	-	15	1,087	117	39	32	30	44	147	4,407
Woodley Island	-	-	-	13	34	-	7	2	26	-	1	-	5	-	88
Indian Island	-	-	25	13	6	-	4	9	195	2	-	-	6	7	267
Bayside Bottoms	1,005	-	-	102	37	-	8	238	81	1	1	8	2	12	1,495
North Spit	33	366	1,646	286	20	7	56	1,056	133	18	15	3	13	3	3,655
Arcata Bottoms	6,278	194	892	330	140	-	23	1,345	213	29	44	24	100	426	10,044
Mad River	607	-	206	189	5	-	54	285	-	4	-	26	51	163	1,590
TOTAL	14,053	759	3,459	3,049	656	18	342	8,385	970	253	182	185	302	960	32,981

¹Discrepancies between figures in this table and Tables VII-2 through VII-9 (Volume II) are explained in Appendix E.

²For a detailed discussion of habitat types and areal extent, see Section II-D, Volume III.

³For each subarea, the "drift line" or the lower limit of vegetation was generally the limit of the area measured.

uses. Exceptions are wooded residential areas, such as parks, where some urban tolerant birds and small mammals are found, and port areas where water-oriented birds, fish and shellfish may be found.

Urban habitat types are centered around the cities of Eureka and Arcata, and the railroad/highway corridor which connects them. These habitat types are also found at Fields Landing and King Salmon, on South Bay, and Manila, Fairhaven and Samoa on North Spit.

The Agriculture habitat types are those pasture and crop lands which are or have been used for commercial farming. Within the study area, grazing of cattle and sheep is the most common farming activity. Most of the agricultural areas are lowlands which were diked and drained to take advantage of the rich alluvial soils found in the floodplain. Prior to diking, these lands were probably at or near intertidal elevations, and were probably wetland habitat types (saline, brackish or fresh). Old tidal channels and sloughs are evident in many of the grazing lands. Often these channels, when combined with drainage ditches, assist in draining low agricultural land.

Some agricultural lands have been noted as wetlands. The soils of these areas are saturated with sufficient frequency to support wetland vegetation. Bent grass (Agrostis alba) and salt grass (Distichlis spicata) are common in these areas. Rush (Juncus spp.), pickleweed (Salicornia virginica) and sandspurry (Spergularia sp.) are also found but not in abundance. See Volume III, p. 13, for further discussion of agriculture/wetlands.

As noted by Monroe (1973), many agricultural lands are flooded during winter rains. These areas are often referred to as seasonal wetlands. Due to the physical, rather than botanical characteristics of these areas, it has not been possible to map their distribution. They are often centered around old tidal channels and other low areas referred to previously. (A more detailed discussion of seasonal wetlands may be found in Volume III.)

Extensive agricultural lands are found between North Bay and Mad River, west of Arcata. There are also agricultural areas along the east shore of North Bay, extending up Jacoby Creek and Freshwater Creek. East of Middle Bay large portions of the Elk River valley are agriculture habitat types. Adjacent to South Bay agricultural lands are found in the vicinity of Hookton Slough and up the Salmon Creek valley.

Grassland habitat types are found in those areas where annual and perennial grasses and forbs dominate and woody species are not present in significant numbers. Since there are few, if any, undisturbed uplands within the Humboldt Bay study area, most grasslands are either abandoned agricultural lands, vacant lots, or roadsides. Grasslands are found in scattered locations throughout the area.

Shrub habitat types are characterized by woody vegetation less than six meters (20 feet) in height. Blackberries (Rubus spp.) and coyote brush (Baccharis pilularis) are most common, but silk-tassel (Garrya elliptica), bayberry (Myrica californica), Indian plum (Osmaronia cerasiformis), and cascara (Rhamnus purshiana) may also be found. The shrub habitat type is not extensive anywhere it is found, but is rather widely scattered throughout the study area. Dense shrub stands are often found on dikes or in long abandoned vacant lots or agricultural lands.

Forested habitat types are found throughout the study area and are characterized by the dominance of deciduous and/or coniferous trees. Although much of the area was originally wooded, only isolated remnants of the pre-settlement forests remain. Many of the wooded areas around Humboldt Bay are second growth which has become established following early timber harvests.

Within the study area, forest habitat type can be subdivided as follows:

- . Deciduous forest
- . Evergreen forest
- . Mixed deciduous/evergreen forest
- . Closed cone pine forest

Successional patterns in Northwest forests have been described by Franklin and Dyrness (1973). Immediately following logging or burning herbaceous annuals and perennials dominate the site. These are soon replaced by shrubs such as blackberries, barberries (Berberis spp.), rhododendron (Rhododendron macrophyllum), and salal (Gaultheria shallon) and salmonberry (Rubus spectabilis). In time a deciduous forest, dominated by alder (Alnus oregana) develops. Introduction of Douglas fir (Pseudotsuga menziesii) and Sitka spruce (Picea sitchensis) leads to a mixed deciduous/evergreen forest. Ultimately the conifers dominate, particularly redwood (Sequoia sempervirens) and Douglas fir. It has been suggested that redwood forests are only a seral stage, albeit a long-lived one, with climax represented by hemlock (Tsuga heterophylla) and tanbark oak (Lithocarpus densiflorus).

Deciduous forest is usually dominated by alder with occasional willow (Salix spp.) or black cottonwood (Populus trichocarpa) intermixed. The latter two species are most common in riparian situations. The understory in deciduous forests may vary from salmonberry or blackberries to sword ferns (Polystichum spp.) and bracken ferns (Pteridium spp.)

Evergreen forest in the Humboldt region is usually a mixture of redwood and Douglas fir. Lowland fir (Abies grandis), Sitka spruce, and alder may also be present. Occasionally, evergreen forest consists of a stand of Eucalyptus spp., an ornamental broadleaf evergreen, present in several locations around the Bay.

The mixed deciduous/evergreen forest does not exhibit a

significant dominance of either evergreen or deciduous species. It is commonly a very diverse assortment of trees from both the previously described forests. In some areas, such as the steep slopes of gulches in Eureka, it may represent a dynamic equilibrium resulting from conditions of light, water and steep slopes. Such an equilibrium might be called an "edaphic climax" (Odum, 1969), where local conditions of soil development and water availability control climax communities, rather than regional climatic conditions.

The closed cone pine forest is found primarily along the coastal strand and is dominated by beach pine (Pinus contorta). Silktassel, Douglas fir and Sitka spruce are also found within the canopy. Evergreen shrubs such as salal, bearberry (Arctostaphylos uva-ursi) and huckleberry (Vaccinium ovatum) are common in the understory.

Riparian forests are those found adjacent to natural watercourses. In the Humboldt Bay area this is generally a narrow band of vegetation along rivers and streams, but it may also be found adjacent to lakes, ponds, or the Bay itself. Riparian habitat types are characterized by the influence of the local water table and often by seasonal flooding. As a result, the overstory may remain similar to the adjacent forest but the understory may contain a variety of plant species adapted to moist or wet substrates. Salmonberry, bayberry, willows, twinberry (Lonicera involucrata), and lady fern (Athyrium felix-femina) may all be more common in the riparian woodland understory than in other forest habitat types.

Forest habitat types are widely distributed throughout the Humboldt Bay region. Deciduous forests are common in the gulches of Eureka. Evergreen forest habitat types are scattered through Eureka and on nearby hillsides. Mixed deciduous/evergreen forests are most common on the sides and bottoms of gulches and also on Table Bluff. The closed cone pine forest is common on North Spit and northward on the coastal strand to approximately Lanphere Road.

Most water habitat types in the study area are associated either with the tidal bay regime or the rivers and creeks entering into the Bay. The water habitat type can be divided into the following categories:

- . Deep tidal channels
- . Shallow tidal channels
- . Tidal creeks and sloughs
- . Creeks and rivers
- . Ditches, ponds, and closed channels.

Deep tidal channels are those areas within the Bay which are subject to maintenance dredging for navigation and commercial purposes. The depth of these channels varies from 12 to 47 feet below mean lower low water (MLLW) and is maintained by the Corps of Engineers (NOAA, 1978). There is a total of 8.6 miles of these channels in the Bay with widths of 300-800 feet.

Deep tidal channels are generally characterized by a dearth of macroscopic vegetation. This is due to both the depth, and subsequent lack of available light, and also the frequent disturbance associated with maintenance dredging activities. There is, however, considerable phytoplankton which occupies the water column in these deep channels (Harding, 1973). The upper limit of deep tidal channels is defined as -12 feet (MLLW).

Shallow tidal channels are more shoal than deep tidal channels and do not undergo periodic maintenance dredging. These natural channels are distributed throughout the Bay and act to drain the mudflats as tide ebbs. The upper limit of shallow tidal channels is defined as MLLW.

The lack of disturbance and the shallow character of these channels allows a few plants to thrive. Eelgrass (*Zostera marina*) may be found along the edges or sometimes at the bottom of these channels. Some algal species, such as sea lettuce (*Ulva* spp.) or filamentous green algae, may also be present in these shallow channels.

Tidal creeks and sloughs are shallow channels which meander through agricultural lands and are usually diked to prevent flooding of the adjacent areas. Often intertidal mudflats will be distributed along these channels. Tidal creeks are characterized by depressed salinities as a result of upland runoff or stream flow into the channel. These areas are defined as tidal channels, thus their upstream limit is the limit of tidal influence. In this study the upstream limit of tidal influence can only be approximated, however, through field examination and review of existing literature. Thus, the upstream limit of tidal areas mapped in this study cannot be considered exact.

Vegetation in tidal creeks and sloughs varies from marine or brackish algae in the channel bottoms, to salt or brackish marsh vegetation along the edges and mudflats. Sea lettuce (*Ulva* spp.), *Enteromorpha*, widgeon grass (*Ruppia maritima*), and pondweed (*Potamogeton* spp.) may be found in the channel bottoms. Salt marsh vegetation near the mouths of these sloughs includes pickleweed and cordgrass (*Spartina foliosa*); brackish marsh vegetation includes bulrush (*Scirpus* spp.), hairgrass (*Deschampsia caespitosa*), and rush.

Hookton Slough, Mad River Slough, and Fay Slough are tidal sloughs with very little freshwater runoff. Jacoby Creek, Eureka Slough, and Elk River Slough are all tidal creeks with a significant amount of freshwater inflow from creeks and rivers.

Creeks and rivers are flowing freshwater bodies bringing water from adjacent watersheds into the Bay. Some of these (e.g. Jacoby Creek, Freshwater and Elk River) are free-flowing with levees to prevent flooding. Others, such as McDaniels Creek and Rocky Gulch, are separated from the Bay by levees and tide gates, thus preventing any tidal intrusion.

Swift flowing rivers often have no vegetation in their channels. However, slow moving rivers and shallow creeks, such as those meandering through floodplains, often have extensive vegetation along the edges and occasionally in the main channel. Cattails (Typha spp.), marsh pennywort (Hydrocotyl sp.), canarygrass (Phalaris arundinacea), and Angelica (Angelica sp.) may all be found in or adjacent to creeks.

Ditches, ponds and closed channels may be described as standing water situations, although under flood conditions there may be some water movement. Farm ponds, drainage ditches, millponds, and cutoff slough channels are all examples of this habitat type.

Phytoplankton and filamentous green algae often fill these areas in the summer, giving the water a turbid appearance. In shallow areas or around the edges cattails, bulrushes, pennywort, and Angelica are common.

A wide variety of wetlands are present in the Humboldt Bay area. Salt marsh, brackish marsh, fresh marsh, swamp, intertidal flat*, and eelgrass are the basic groups into which the various wetlands may be classified. Each group has unique water regime, substrate, and vegetation characteristics which distinguish it from the others.

[For this report, wetlands are defined according to Corps regulations 33 CFR 323.2. (For further discussion of this definition see Volume III.) Several other definitions of wetlands exist. Most notable of these is that of the U.S. Fish and Wildlife Service (USFWS) which identifies wetlands according to the presence of hydric soils. Hydric soils are defined as wet, poorly drained soils, often consisting of large amounts of organic peat and muck. These soils often support communities of hydrophytic plants.]

Salt marshes are habitat types which are inundated by marine waters with sufficient frequency that only certain salt and water tolerant plant species can become established. These areas are usually found along the fringes of the Bay or tidal sloughs. There are also a few examples of this habitat type in agricultural areas where leaking tidegates allow Bay water to enter.

Two vegetation associations have been identified in salt marshes. The cordgrass association is generally found at middle and high elevations within the marsh. Cordgrass generally exhibits a cover of 75% or more in this habitat type. Pickleweed and saltgrass may also be present in small amounts.

* Interpretation of Corps regulations (33 CFR 323.2) suggests that intertidal flats are not considered wetlands if unvegetated. They are still within Corps jurisdiction as navigable waters.

The pickleweed-saltgrass association is characterized by a low mat of vegetation which may be found from the lowest to the highest elevations of the salt marsh. At the lowest elevations pickleweed dominates with saltgrass usually present in measurable amounts. With increased elevation, the diversity of this association increases. Jaumea (Jaumea carnosa), orache (Atriplex patula), sea lavender (Limonium californicum), arrowgrass (Triglochin maritimum) and gumweed (Grindelia stricta) are all common, but never dominant in higher elevation pickleweed marshes. Of particular interest in these higher elevation areas are Humboldt Bay tarweed (Grindelia stricta spp. Blakei) and Humboldt Bay owl's clover (Orthocarpus castillejoides Var. humboldtensis), both considered uncommon endemic species of Humboldt Bay.

[It should be noted that the vegetation zonation described in Humboldt Bay disagrees with that described for San Francisco Bay (Mahall and Park, 1976). For a further discussion of the differences, see Volume III of this report.]

Brackish marsh is a tidal wetland experiencing inundation by low salinity water. Often this habitat type is found at the very highest marsh elevation, where runoff may dilute infrequent tides, or adjacent to rivers and creeks where a constant freshwater flow results in depressed salinities. Two brackish marsh associations have been recognized in the Humboldt Bay region.

Hairgrass dominates one brackish marsh type, although rush (Juncus patens), bentgrass, and silverweed (Potentilla sp.) are also present. Arrowgrass and yarrow (Achillea millefolium) may be found, but rarely in more than spotty locations.

The other common brackish marsh habitat type is dominated by sedge (Carex obnupta). This is usually a dense monotypic community with no other species present.

Several different fresh marsh habitat types have been identified. These are most often associated with rivers or creeks in the area, or alternatively, closed channel habitat types such as millponds or drainage ditches. In some situations they are tidelands originally diked for agricultural purposes which maintain a wetland character, having changed from salt marsh to fresh marsh.

A common fresh marsh in the area is dominated by Angelica, with occasional rush and marsh pennywort. This habitat type is often inundated with several inches of water and has a soft, boggy substrate.

Another common fresh marsh habitat type is dominated by rush with some sedge, bulrush (Scirpus fluviatile) or silverweed scattered throughout. This habitat type is usually found on a moist, but firm, substrate and is only rarely inundated.

Cattails also make up a major fresh marsh habitat type. They are usually found in monospecific associations with varying water regimes. Often cattails are found in drainage ditches or along the shores of slow moving creeks.

Swamps are wetlands dominated by trees and shrubs. Willows are usually the dominant tree, although alder may also be present. Swamp understory usually includes salmonberry, sedge, buttercup (Ranunculus sp.), and bulrush. Angelica may also be present in especially boggy situations.

In the dune areas of North Spit, swamps have a slightly different character. In addition to the willows, beach pine and Sitka spruce may also be a part of the overstory. The shrub understory may contain bayberry, twinberry (Lonicera involucrata), and huckleberry. Low understory species may include silverweed (Potentilla Egedii grandis), sedge, bracken fern (Pteridium aquilinum), and dock (Rumex crassus) (Johnson 1963).

Broad expanses of Humboldt Bay consist of intertidal flat habitat types, extending from the shore of the Bay out to the edges of the shallow and deep tidal channels. For this study, extreme low water (ELW) has been chosen at the lower limit of intertidal flats. In general, ELW corresponds to approximately -3 feet (MLLW). Most of the flats are bare above an elevation of about +1 MLLW, with only diatoms or occasional patches of algae.

Below the +1 contour, dense stands of eelgrass dominate most of the mudflats, and extend at least partially into adjacent channels (Keller, 1963). The lower limit of eelgrass stands is dependent on light penetration, nutrients, and numerous other parameters. In Humboldt Bay, studies of eelgrass have gone to a depth of -1.5 (MLLW) but no maximum depth was noted (Harding and Butler, 1979). Phillips (1974) reported eelgrass to -22 feet (MLLW) in Puget Sound and below -50 feet (MLLW) in La Jolla Canyon. Almost all flats except those subject to regular oyster harvest are covered (Monroe, 1973). These stands of eelgrass are monotypic, but they may support a variety of epiphytic algae.

Both North and South Spit exhibit distinct and unique (for the study area) dune habitat types. The windblown sand and salt spray create a highly stressed environment which can be tolerated by a limited number of organisms.

Bare dunes are unvegetated areas, often characterized by large amounts of moving sand.

Vegetated dunes have been reasonably stabilized by a variety of grasses, forbs, and shrubs. Bush lupine (Lupine spp.), seapink (Armeria maritima californica), bluegrass (Poa spp.) and goldenrod (Solidago spathulata) are all common on heavily vegetated, stabilized dunes (Johnson, 1963; Barker, 1976).

Sparsely vegetated dunes are usually less stabilized than vegetated dunes, and represent a more mobile sand substrate. Most foredunes on the spit are included in this habitat type. Beachgrass (Ammophila arenaria), dune grass (Elymus mollis), sea rocket (Cakile spp), ice plant (Mesembryanthemum chilense), and beach strawberry (Fraxeria chiloensis) are often found on sparsely vegetated dunes. The wallflower (Erysimum menziesii), identified as threatened (Smithsonian, 1975), has been reported from this habitat type (ERC, 1977).

Dune hollows are low, blown-out areas between dunes which are closer to the water table, protected from the wind, and therefore a more conducive habitat for vegetation. A variety of shrubs such as bearberry (Arctostaphylos uva-ursi), coyote brush (Baccharis pilularis), blackberry (Rubus ursinus) and bayberry (Myrica californica), may be found in these hollows. Rush (Juncus lesueurii), birdsfoot trefoil (Lotus micranthus), and sedge (Carex obnupta) are important components of the understory.

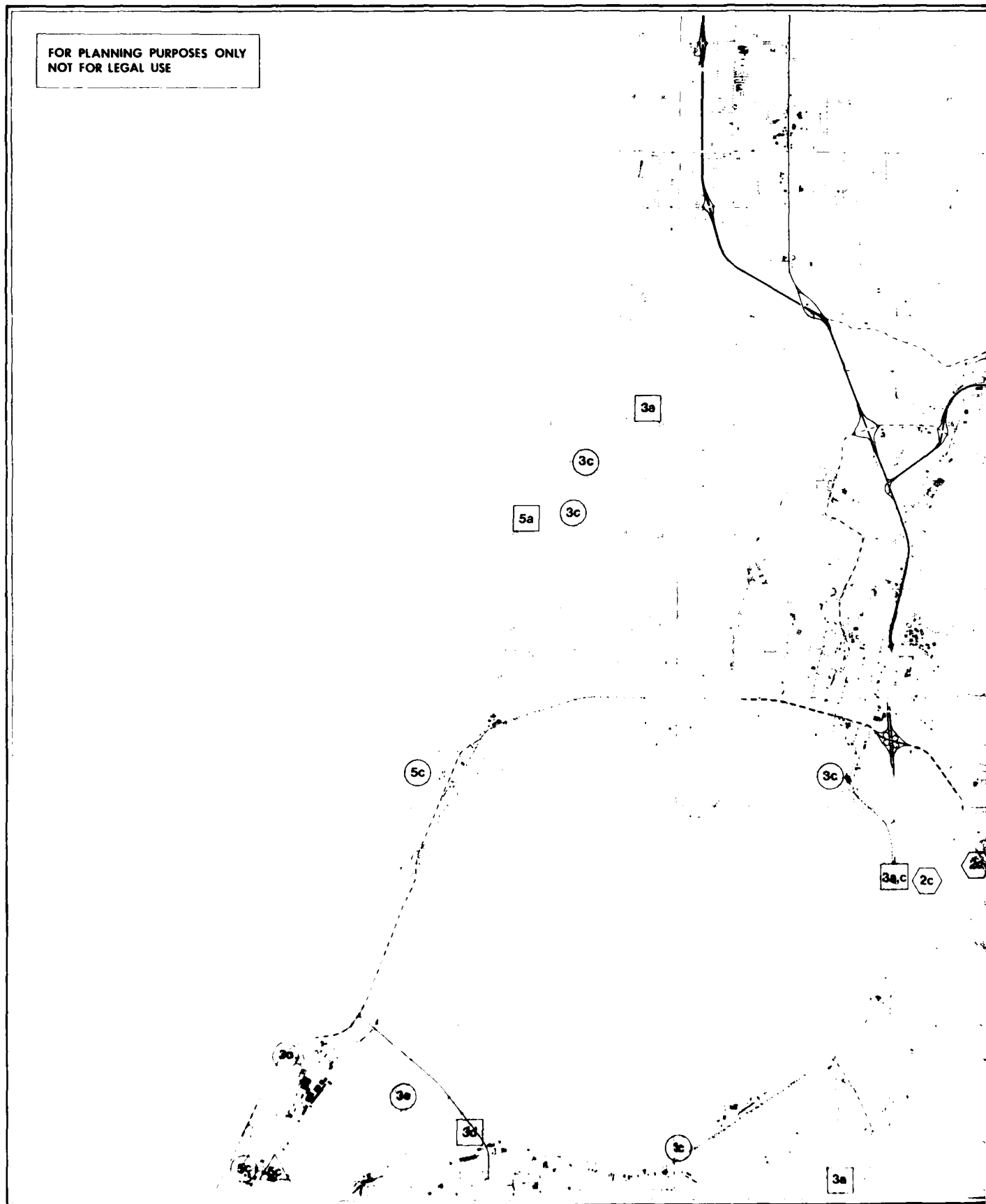
Jetties and reefs are man-made structures usually constructed from impermeable substrates. Rocks, concrete, and tires are important examples of construction materials in the Humboldt Bay area. Although they do not support flowering plants, a prolific and diverse algal community usually develops on the intertidal and subtidal portions of these habitat types. Green, red and brown algae are usually distributed over most of the substrate.

Rare and Endangered Species

Six plant species identified in the Humboldt Bay area have been described as rare or endangered. Of these only one, Cordylanthus maritimus ssp. maritimus, has been listed as endangered by USFWS under the Rare and Endangered Species Act (PL 93-205). Two others, Lilium occidentale and Orthocarpus castillejoides var. humboldtensis, have been proposed as endangered (41 FR 24525-72). Two more, Cordylanthus maritimus ssp. palustris and Erysimum menziesii, have been listed as candidate threatened (40 FR 27837-46). The final status of these last four species will be determined by USFWS before 1 January 1980. In addition to the above species Monotropa uniflora has been noted as as rare in California (CNPS, 1974); this status has not been recognized by USFWS to date. Plate 11 shows the known distribution of these plants.

[According to a notice published in the Federal Register, 10 December 1979, the status of both proposed endangered species (L. occidentale and O. castillejoides var. humboldtensis) has been changed to candidate threatened or endangered (44 FR 70796-97).]

FOR PLANNING PURPOSES ONLY
NOT FOR LEGAL USE



RARE & ENDANGERED PLANTS

PLATE NO 11 NORTH

LEGEND

LISTED ENDANGERED

- 1 Cordylanthus maritimus
ssp. maritimus

PROPOSED ENDANGERED*

- 2 Lilium occidentale
3 Orthocarpus castillejoide
var. humboldtensis

CANDIDATE THREATENED

- 4 Cordylanthus maritimus
ssp. palustris
5 Erysimum menziesii

RECOMMENDED (CNPS, 1974)

- 6 Monotropa uniflora

COLLECTION OR OBSERVATION

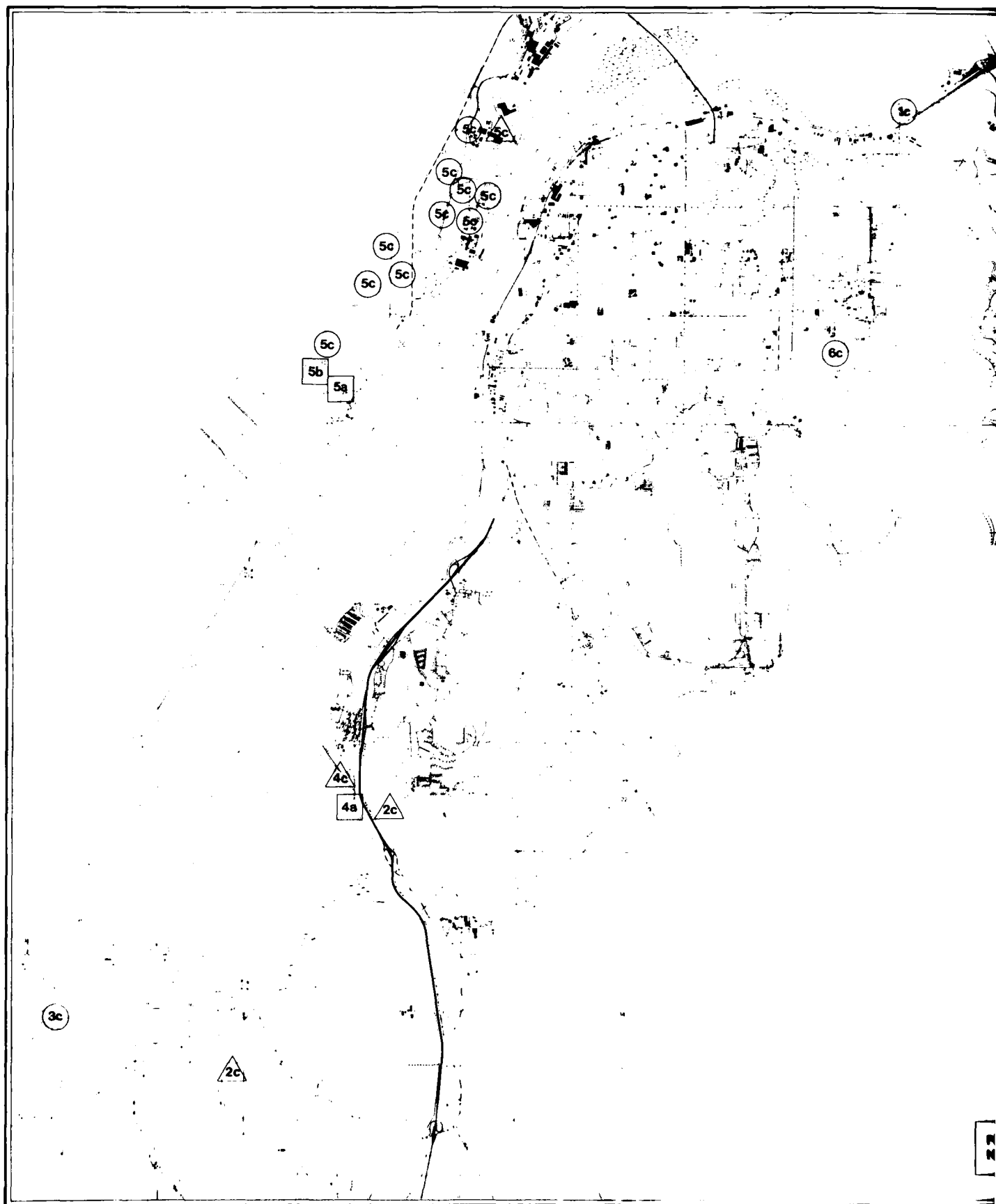
- Recent (1975 - Present)
○ 1945 - 1975
△ Pre - 1945
◇ Historical



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

- Source: a This Study
b ERC 1975a
c CNPS 1974
d ERC 1975b
e CNACC 1975

*Revised to Candidate Threatened or Endangered
Dec 1979 (44 FR 70796-97)



RARE & ENDANGERED PLANTS

PLATE NO 11 SOUTH

LEGEND

LISTED ENDANGERED

- 1 Cordylanthus maritimus
ssp. maritimus

PROPOSED ENDANGERED*

- 2 Lilium occidentale
- 3 Orthocarpus castilleoides
var. humboldtensis

CANDIDATE THREATENED

- 4 Cordylanthus maritimus
ssp. palustris
- 5 Erysimum menziesii

RECOMMENDED (CNPS, 1974)

- 6 Monotropa uniflora

COLLECTION OR OBSERVATION

- ☐ Recent (1975 - Present)
- ☐ 1945 - 1975
- Pre - 1945
- Historical



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

- Source
- a This Study
 - b ERC 1975a
 - c CNPS 1974
 - d ERC 1975b
 - e CNACC 1975

*Revised to Candidate Threatened or Endangered
Dec 1979 (44 FR 70796-97)

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M. MAMMALS

Mammals occurring in the Humboldt Bay area include 86 species and subspecies (Table E-4, Appendix E) which may be divided into five general categories: Big game, carnivores, furbearers, small animals, and marine mammals. Information available on members of each of these groups is summarized below and supporting data relevant to occurrence, habitat preferences, feeding and reproduction are presented in Tables VI-10 and VI-11. No comprehensive surveys of occurrence or habitat utilization have been made for mammals in the study area. An inventory list has been provided by the California Department of Fish and Game (Monroe, 1973), and general considerations for species occurring in wetlands have been discussed (Cal. Fish and Game, 1971). Information utilized in the present report is derived from Ingles (1965), Dasmann (1975), Daugherty (1972), Schempf and White (1977), and additional specific references cited below. In subjects where data is lacking, extrapolation from generalized mammal literature forms the basis of information. Specimen catalogs at the Humboldt State University Museum of Zoology and the University of California Museum of Vertebrate Zoology were also examined. Table E-4 (Appendix E) summarizes the status, quality of information, and habitat utilization of all mammalian species actually or potentially occurring in the Humboldt Bay wetlands and adjacent areas.

Big Game

Big game species potentially using the study area include black-tailed deer, black bear, and Roosevelt elk. Only deer are regular users of the immediate area, but several of the remaining species are sighted occasionally as described below.

Black-tailed deer are common in the study area, and occasionally seen in morning and evening hours. Their occurrence is probably sporadic depending on population numbers and food availability in surrounding watershed areas. Deer are primarily browsers, feeding on the shoots of shrubs and young trees in preference to older woody material or grass. In the region of the study area black-tailed deer have been shown to prefer leaves of blackberry and salal, and twigs or stems of huckleberry, cascara, and douglas fir seedlings. They will also feed on alder, hazel, and vine maple (Crouch, 1966, Tables 1, 2) when leafy forage is unavailable. Douglas fir is the most preferred of the woody species, and Crouch (1966) has shown that as the availability of leafy forage declines, utilization of douglas fir increases. When preferred native forage is in short supply relative to deer numbers, depredations on timber plantations (Lauppe, 1963; Browning and Lauppe, 1964) and farm and garden crops are frequently observed.

Roosevelt elk are potential users of the study area. Historically, elk are likely to have occurred but they have not been reported in recent years. Elk are grazers, feeding most frequently

in grassland or meadow areas and seeking cover in nearby forest or woodland. When population numbers exceed carrying capacity of the habitat in interior areas of the county, elk may appear more frequently in agricultural and rural situations. Under conditions of food stress, elk may damage the bark of trees and begin browsing on the twigs of orchard trees.

Black bear have occurred historically in the study area and apparently are common in adjacent forested areas. A sighting occurred recently near Arcata (Bob Sullivan, Humboldt State University Museum of Zoology, personal communication), and the bear kill for the county indicates no decline in numbers for this species (Outdoor California, 1967). Bears are omnivores, feeding primarily on grubs, tubers, berries, small mammals, and fish.

Carnivores

Mountain lion. Occurring historically in the study area, this species has not been reported in recent years but is an uncommon resident in forested areas around the bay (P. McLaughlin, California Fish and Game, personal communication). Mountain lions are thought to be found wherever deer occur, and in the Rocky Mountain states they are known to come very close to urban areas, usually without detection. The primary prey of this carnivore is the black-tailed deer in this area, although depredation of sheep is sometimes attributed to the species.

Bobcat. A carnivore preying primarily on small mammals and birds, this species is known to occur at least infrequently in the study area.

Gray Fox. The status of this species in the study area is not known but it is expected to be found on the basis of its occurrence in many different plant communities of the Sonoran and Transition life zones throughout California and western Oregon. This carnivore feeds chiefly on small mammals, insects, and occasional young birds. It is expected in closed-cone pine woodland, shrub, and grassland habitats of the study area and may also hunt in vegetated dune areas.

Coyotes have successfully coexisted with man in many agricultural and rural areas in spite of attempts to eradicate them. Their status in the study area apparently is not documented. While not common, they may be expected in a variety of habitats including grassland, shrubland, woodland, forest, dune and marsh habitats. They feed primarily on insects, birds, and small mammals up to the size of a jack rabbit. Their depredations on sheep are probably over-exaggerated in many cases.

Furbearers

Seven species of furbearers potentially occur in the Humboldt Bay wetlands: Beaver, raccoon, Marten, Fisher, mink, and river otter. The wolverine is increasing in numbers in northern California (Yocum, 1973), but there have been no recent records from Humboldt County. Information on furbearers summarized by Shempf and White (1977) is presented in Table VI-10.

Beaver. No records of recent collection of this species from the study area were found. Beaver require relatively gently descending water courses for dam construction (primary or secondary streams) and an abundance of trees in the immediate vicinity for both construction and food. The absence of these conditions, perhaps compounded by human depredations, may explain the apparent current absence of this species from the study area. Beaver may occur in tributary streams to the Mad River within or near the study area. They are not likely inhabitants of the river proper, as they typically avoid larger streams.

Raccoon. While no specimens from the study area were found in the museum search, this species probably does occur in the study area. An omnivore, the raccoon has adapted easily to agricultural and even urban situations often raiding garbage cans, fish ponds, etc. No information on its status in the Humboldt Bay area was available.

Ringtail, a close relative of the raccoon, inhabits brushy, rocky slopes and is strictly nocturnal (Ingles, 1965). For these reasons, the species is seldom observed even where it is known to be common. No records were found from the study. Food of this species includes small rodents and birds and fruit of several dry shrub community species (manzanita, cascara, and madrone). Daylight hours are spent in a permanent den usually situated in a hollow tree or rock pile. Woodland is its preferred habitat in the north coast counties (Schempf and White, 1977). If present in the study area, the Ringtail probably occurs on the drier slopes and ravines of hills in the vicinity.

Marten, in north coast counties, generally occurs at higher elevations of 3000-6000 feet in mixed conifer and Douglas Fir woodland. Although unlikely to occur in the study area and generally uncommon, its numbers appear to be increasing (Schempf and White, 1977). A predator on squirrels and other small mammals, the species probably occurred historically in the area.

Fisher. Common and increasing in numbers in north coast counties (Schempf and White, 1977), this species prefers Douglas Fir and mixed conifer habitats at altitudes generally higher than those found in the study area. No records of its occurrence in the immediate bay area was found, but individuals may potentially range into the neighboring forested areas. The Fisher's food includes mammals and birds--porcupines, squirrels, wood rats, mice, beaver, quail and grouse.

Table VI-10

SUMMARY OF RESULTS OF FURBEARER SURVEY (Schempf and White, 1977)

Summary of the furbearer survey.

Species	Region	Number of records	Most important vegetation types	Average elevation ± 1 S.D.	Status	Trends
Ringtail	North Coast	37	Woodland	1900 ± 900	Common	Increasing
	North Sierra	31	Mixed conifer	2800 ± 1600	Common	Increasing
	South Sierra	79	Woodland, Mixed conifer	3900 ± 1700	Common	Increasing
	Composite	147	Woodland	3200 ± 1700	Common	Increasing
Marten	North Coast	34	Mixed conifer, Douglas Fir	4700 ± 1900	Uncommon	Increasing
	North Sierra	189	Fir, Lodgepole	6600 ± 1600	Common	Increasing
	South Sierra	171	Lodgepole	8300 ± 1500	Common	Increasing
	Composite	394	Fir, Lodgepole	7200 ± 1800	Common	Increasing
Fisher	North Coast	108	Douglas Fir, Mixed conifer	3200 ± 1600	Common	Increasing
	North Sierra	18	Fir, Lodgepole	5500 ± 2100	Rare	Static
	South Sierra	80	Mixed conifer	6800 ± 2000	Uncommon	Decreasing
	Composite	206	Mixed conifer, Douglas Fir	4800 ± 2500	Uncommon	Increasing
Wolverine	North Coast	17	Douglas Fir, Mixed conifer	2800 ± 1200	Rare	Increasing
	North Sierra	16	Mixed conifer, lodgepole	5800 ± 1500	Rare	Increasing
	South Sierra	110	Lodgepole	8600 ± 2200	Uncommon	Increasing
	Composite	143	Lodgepole	7600 ± 2800	Uncommon	Increasing
River Otter	North Coast	73	Mixed conifer, woodland	1500 ± 700	Common	Increasing
	North Sierra	27	Pine	3300 ± 2700	Uncommon	Increasing
	South Sierra	36	Lodgepole	6100 ± 2800	Uncommon	Increasing
	Composite	136	Mixed conifer	3100 ± 2700	Common	Increasing
Red Fox	North Sierra	37	Fir, Mixed conifer	6400 ± 1600	Rare	Static, decreasing
	South Sierra	25	Mixed conifer, lodgepole	6900 ± 2400	Rare	Static, decreasing
	Composite	62	Mixed conifer	6600 ± 5100	Rare	Static, decreasing

Mink. This semi-aquatic species, may range far from its preferred habitat around streams or cattail marshes of inland lakes or ponds. No records of occurrence were found for the study area, but mink are found in all life zones and have been recorded eating dead fish washed up from the ocean (Ingles, 1965). The food of this predator includes fish, frogs, crayfish, mice muskrats, rabbits, and birds (particularly water birds). Ingles (1965) reports that mink have been known to cache coots, ducks, and muskrats for later consumption during the winter.

River Otter has been reported to be common in the Humboldt Bay drainage basin. It prefers mixed conifer, and woodland habitats in the vicinity of stream and river courses. Although primarily nocturnal, the otter may be seen hunting and playing during daylight hours. Food items include fish, frogs, turtles, crayfish, insects, and occasionally young birds. Although fast enough in the water to catch trout, otters generally prey on "rough" fish that eat trout eggs (Ingles, 1965) and therefore pose little threat to the trout fisherman.

Small Mammals

For purposes of this report, small mammals include all species of non-furbearers as large as or smaller than the Jack rabbit. Five groups will be described briefly below: Insectivores (shrews and moles), rodents (squirrels, rats and mice, gophers, and porcupines), rabbits, small carnivores (weasels and skunks) and bats. Very little information is available on members of these groups for the study area. Unpublished summaries of trends in winter populations of small mammal species in Arcata bottoms have been prepared by Levenson and Norris (1973) and Levenson and Frake (1974). Very limited records of occurrence and habitat use of one insectivore and two rodent species are presented by Yull (1972) and by Burton (1972) in connection with studies of predatory birds.

Insectivores, as their name implies, are carnivorous and feed primarily on insects found in various habitats. Shrews are typically found near water in forested areas or in wetland areas with good cover. They eat arthropods and some plants. Since they have very high metabolic rates and since a large part of their insect food is essentially indigestible (the chitinous exoskeleton), they must consume large quantities of insects daily. Consequently, they are probably important in limiting certain insect populations and they are susceptible to bio-amplification of environmental toxins (concentration by passage up the food chain). Moles are fossorial (i.e., spend their lives underground) and feed principally on arthropods which also spend most of their lives in the soil. Although moles occasionally do damage to lawns and gardens by their digging activities, they are entirely beneficial members of the animal community.

Rodents form a diverse group occupying a wide variety of habitats in the study area. Nearly all species of concern here are herbivores.

The Mountain Beaver lives in burrows under dense cover of thimbleberries, salmonberries, and wild blackberries in open spaces of forest. Nocturnal, and semi-fossorial in habit, this species is rarely seen, but was trapped successfully in the study area by Goslow (1964), who reports it as early as 1929. Its food consists primarily of thimbleberry, salmonberry, blackberry, creek dogwood, fireweed, bracken fern, skunk cabbage, nettle, lupine, salal, and willow (Ingles, 1965). In winter at higher altitudes, the mountain beaver may burrow long distances under the snow to feed on the bark of young white fir. This species can do considerable damage to flower gardens, vegetable crops, and berry patches.

Three groups of squirrels are potentially found in the study area: Ground squirrel, chipmunks, and tree squirrels. The Beechey ground squirrel is semi-fossorial, digging burrows in well-drained soil in a variety of habitats from dune to forest edge and feeding on the surface of the ground. Chipmunks live in less extensive nest burrows and are more frequent in woodland and forest situations. Three species may potentially occur in the study area, although only the Townsend chipmunk is known to be present. Chipmunks feed chiefly on seeds and fruits but may also take insects and fungi. Three species of tree squirrels are expected in the study area. The Western gray squirrel is characteristic of deciduous or mixed woodlands and eats mostly acorns. The Douglas squirrel occurs most frequently in areas of Douglas fir and closed-cone pine; its primary food is pine seeds. The Flying squirrel may occur in most woodland and forest habitats but is rarely observed, being almost entirely nocturnal in habit. It gains most of its nutrition from fungi in the summer and from hair moss (*Alectoria fremonti*) in the winter. It may also consume nuts, fruit, and insects.

Two species of gophers may potentially occur in the study area. These fossorial animals construct burrow systems in search of both insect and plant food in a variety of habitats. The botta gopher is known to appear in vegetated dune areas around Humboldt Bay. The status of the Mazama gopher in the study area is not known. Burrowing by gophers may cause damage to gardens and crops but is beneficial in most areas, turning and aerating the soil and providing appropriate micro-environments for salamanders, toads, snakes, mice, and arthropods (Ingles, 1965).

At least 14 species of New and Old World rats and mice and voles occur in habitats in the study area. Voles are semi-fossorial, living in subterranean burrows and constructing runways through vegetation on the surface of the ground in the course of eating grasses and forbs. Vole populations show fluctuations in abundance that have been termed "cycles." Both New World and Old World mice feed chiefly on seeds and cultivated grains. Deer mice are found in

nearly all habitats and occur around human dwellings in rural or undeveloped settings. House mice are largely restricted to areas around human habitations in urban as well as rural situations. The native Wood rat is mostly nocturnal, spending the daytime in a stick nest constructed under cover of dense vegetation in woodland habitats. Wood rats are herbivores, feeding extensively on green vegetation. The old world rats, the Norway rat and the Black rat, are found in the vicinity of poorly maintained human constructions and around dumps, wherever garbage is freely available; they may also eat small mammals and young birds on opportunity.

Although basically arboreal (tree-climbing) in its native habitat, the porcupine has become common in a variety of habitats in the Humboldt Bay area including urban, agricultural, grass and shrubland, as well as woodland and forest situations. Porcupines normally feed on a variety of plant foods, and strip bark from trees mainly during the winter and periods of drought. They readily eat various fruit and vegetable crops raised and stored in agricultural areas and this, coupled with their virtual immunity to predation, probably explains their increased occurrence in the study area.

Rabbits and Hares. Two species from this group occur commonly in the study area. The black-tailed hare characteristically occurs in a variety of habitats, eats a diverse array of herbs and shrubs including many cultivated plants, and has adapted readily to human disturbance. In the study area it is known to be common in grassland, and vegetated dune areas. The brush rabbit is much more retiring, occurring only in densely vegetated areas and feeding only tentatively in open areas. Plant foods eaten by the brush rabbit have been identified by Shields (1958); these are listed in Table VI-11.

Small carnivores. Weasels and skunks are common in the study area. The long-tailed weasel has been reported from vegetated dune areas and is probably present in forested areas as well. The short-tailed weasel or ermine is more frequently found at higher altitudes and may not occur in the vicinity of the Bay. Weasels are the principle predators of other small mammal species, and often feed on birds, snakes, and insects. Two species of skunk are likely to be found in the study area. The striped skunk often inhabits logged-over areas, weed-grown fields, and streamside thickets, while the spotted skunk is more characteristic of drier habitats where it often takes over old ground squirrel burrows. Striped skunks also occur in dunes which are sufficiently vegetated that soil is stabilized for burrow digging; in these areas, skunks hunt along the beach, eating dead animals washed in by the tide and digging up crabs. Both species feed principally on insects, rodents, small birds and possibly bird eggs (Ingles, 1965).

Table VI-11

List of plants known to be eaten by
brush rabbits on the North Spit of
Humboldt County (taken from Shields, 1958)

<u>Scientific Name</u>	<u>Common Name</u>	<u>Number of Observations*</u>
<u>Lupinus arboreus</u>	Bush lupine	103
<u>Montia perfoliata</u>	Miner's lettuce	66
<u>Achillea millefolium</u>	Common yarrow	50
<u>Medicago hispida</u>	Bur clover	24
<u>Poa sp.</u>	Blue grass	17
<u>Festuca sp.</u>	Annual fescue	10
<u>Solidago spathulata</u>	Coast goldenrod	10
<u>Tanacetum camphoratum</u>	Dune tansy	8
<u>Juncus lesueurii</u>	Salt rush	7
<u>Rumex acetosella</u>	Sheep sorrel	6
<u>Poa macrantha</u>	Beach blue grass	4
<u>Abronia latifolia</u>	Sand vergena	3
<u>Ammophila arenaria</u>	Beach grass	3
<u>Cardamine oligosperma</u>	Cardamine	2
<u>Carex obnupta</u>	Slough sedge	2
<u>Erechtites arguta</u>	New Zealand fireweed	1
<u>Erechtites prenanthoides</u>	Australian fireweed	1
<u>Scrophularia californica</u>	California bee plant	1
<u>Stellaria media</u>	Common chickweed	1
<u>Eriophyllum staechadifolium</u>	Lizard tail	1
<u>Cerastium sp.</u>	Power horn	
Unidentified Compositae	Compositae	

*Number of times a species was recorded as having been eaten,
either through sight observations or by walking through an
area and listing the plant species which had been utilized.

Bats. Thirteen species of bats potentially occur in the study area. Little is known about the roosting sites and feeding habitat preferences of most of these species, and no information is available which is directly relevant to the study area. This is an unfortunate situation since bats are extremely important in limiting certain insect populations, and are, at the same time, very susceptible to the toxic effects of insecticides concentrated in the food chain.

Marine Mammals

Marine mammals utilizing resources of Humboldt Bay and the near-shore waters include members of two groups, the Cetacea (porpoises and whales) and the Carnivora (seals and sea lions). Seventeen species of marine mammals potentially occur in the study area. A considerable literature is available on many of these species, although information pertinent to the Humboldt Bay region is restricted to a few studies of the harbor seal and a census of seal and sea lion numbers.

Whales and Porpoises. Sullivan and Houck (unpublished MS) have summarized all information on recorded sightings and strandings in the Humboldt Bay area of 15 species of cetacea. The inventory presented in Table E-4 (Appendix E) is based largely on these data. Little information is available on the food habits of these species. Some data is available for the gray whale (Pike, 1962), and Risso's dolphin (Orr, 1966), and the killer whale (Rice, 1968). Five species in this group have been officially designated as "endangered" (Blue Whale, Hump-backed Whale, Sei Whale, Sperm Whale, and Right Whale) and one has been designated "rare" (Gray Whale).

Seals and Sea Lions. Several studies in the Humboldt Bay area have examined the abundance, distribution and ecology of seals and sea lions. The results of five censuses based on aerial counts between 1958 and 1970 are presented by Carlisle and Aplin (1971). Steller and California sea lions could not be distinguished from the air and so are lumped in these summaries. The data indicate a general decline in numbers of seals and sea lions along the Northern California coastline. The data also indicate that the numbers of sea lions on rookeries and hauling grounds in the segment containing Humboldt Bay remained about the same (ca. 1000) while numbers of harbor seals in the same area actually increased. The implication is that Humboldt Bay and its adjacent coastline are becoming more critical areas for breeding and maintenance of seal and sea lion populations as other segments of coastline are progressively modified or in some way made less attractive or useful to these species. More intensive study of population trends and distributions will be necessary to establish the validity of this suggestion.

Studies of harbor seals in Humboldt Bay have shown that use of haul-out areas is seasonal and most frequent during the pupping period, April to June (Rosenthal, 1968). Seals haul-out on mudflats exposed during ebb tides (Loughlin, 1974). Haul-out locations identified by Loughlin (1974) and Rosenthal (1968) are shown in Plate 12. While these probably are not the only important hauling areas, the locations shown and those around the mouth of the Eel River are the only ones which have been identified in the area.

The harbor seal is an active predator, pursuing and feeding primarily on fish but occasionally taking invertebrates as well (Scheffer and Slipp, 1944 cited by Loughlin, 1974). Harbor seals in Humboldt Bay are known to feed on flatfish, surfperch, eelpout, greenling, and tomcod. Outside the Bay proper, seals add hake and hagfish to their diet. Jones (1979) found surfperch constituting 41.9 percent stomach samples. Less important components of the seal diet include cephalopods (Jones, 1979) and other invertebrates [worms, cockle, crab, shrimp, clam, mussel (Scheffer and Slipp, 1944; Wilke, 1954)].

Other Species

Two species not presently occurring in the Humboldt Bay area may require consideration in the future. These are the Sea Otter and the pelagic fur seal.

The Sea Otter probably occurred in the vicinity of the study area within historic times, and its recovery from near extinction in other areas suggests that this species may one day re-invade the north coast. Studies of feeding behavior (Ebert, 1968; Vandever, 1969), habitat preferences, and natural range extensions (Orr, 1964) have identified conditions necessary for transplantation of the Sea Otter.

The pelagic fur seal has been recorded breeding on islands off California (Peterson, LeBoeuf and DeLong, 1968) where research on population structure, pregnancy rate, feeding, etc. of this species at sea has been carried out (Fiscus and Kajimura, 1965). The fur seal may become more abundant in the near-shore waters around Humboldt Bay, at least at certain times of year, and will obviously be a subject of concern in that event.

Habitat Use by Mammals

A general indication of the importance of various habitat types to mammalian species is provided by the index of species diversity by habitat shown at the end of Table E-4 (Appendix E). The species totals shown are probably underestimates of habitat utilization for two reasons. First, in the body of the table use of a

habitat type by a species is indicated only if that habitat is known to be of primary importance to the species or if general knowledge or actual sightings indicate that the species is frequently found using the habitat. Since many species of mammals are unobtrusive and/or nocturnal in habit, some may use certain areas undetected. Field work in the study area would be necessary to determine the frequency and importance of such use. Second, mammals often carry out various of their activities in different habitats, and so prefer areas where the necessary habitat types are juxtaposed in a convenient way. For example, deer often browse in open, brushy areas, rest in nearby woodland or forest areas providing some cover, and retire deeper into forest areas to bed down during the day. For this reason, more species of mammals are found in ecotone areas (where two habitat types meet) than in large continuous areas of a given habitat type. This phenomenon is called the "edge effect." The following generalizations concerning habitat use must be considered with the edge effect in mind.

Urban areas in the vicinity of Humboldt Bay are used by about 15 species of mammals. Although features associated with dense human and domestic animal populations (buildings, roads, absence of ground cover, etc.) make the urban environment unfit for occupation by many mammalian species, some species persist and even thrive in such areas. Rats and mice have lived in association with humans for centuries; the species introduced from the Old World actually live only around human habitations and waste areas. Moles and gophers frequently invade lawns, parks, and vacant lots. Where trees are present in sufficient numbers, tree squirrels can usually be found. Ground squirrels may occur along road banks or on undeveloped sites of disturbed but well-drained ground. Several bat species may forage for insects, primarily in evening hours, over urban areas; the smaller, low flying species will restrict their activity to vegetated areas where insects are abundant. Porcupines are known to appear in urban areas and raccoons probably do also. Deer may visit fields and gardens on the margins of urbanized areas.

Agricultural areas are potentially used by about 23 species of mammals found in the Humboldt Bay area. The abundance of vegetable foods, relatively little disturbance by daily human activity and the presence of certain kinds of cover objects (trees, fence rows, weed patches) make such areas more attractive to some species than most other areas of high human impact. Small mammals, such as rats, mice, rabbits, ground and tree squirrels, weasels, skunks, raccoons, and porcupine, may be common. Larger species including deer, fox, coyote, and on rare occasions, elk and bear, may appear.

Grassland areas are utilized by most of the species appearing in agricultural areas and some others which tolerate even less human disturbance; about 26 species of herbivorous and insectivorous

small mammals may abound here, where food is abundant and cover is not disturbed by agricultural activities. Predators including skunks, weasels, fox, coyote, may be present. Deer and occasionally elk may appear. Bats forage over grassland areas, especially those which are low-lying or irrigated and hence productive of emerging insects.

Shrub habitats potentially support activities of about 30 mammalian species in the study area. Most species found in grasslands also occur in shrublands where better cover and more diverse food plants support populations of herbivores which in turn provide food for predators. In the Humboldt Bay area, bobcat may appear in search of rabbits or other small game, and mountain lion may occasionally visit in pursuit of deer. The spotted skunk is characteristic of dry shrub areas and the ringtail has been collected under similar conditions in the study area. Coyote and fox may occur relatively commonly.

Forest habitat types generally support the most diverse assemblage of mammalian species, with 40 to 50 species potentially occurring in such portions of the study area. Mature forests unmodified by man support the highest species diversity, but dense, even-aged stands in lumbered areas may be quite sterile. While some species adapted to open areas are absent or infrequent in the forest or woodland, in general such areas provide better cover, and greater protection from human disturbance than the habitats previously discussed. Many species which forage in grassland or shrub areas return to the forest to nests, burrows or resting sites. Ground-dwelling and burrowing rodents are found on the forest floor, particularly where openings provide for the growth of ground cover. Tree squirrels and chipmunks have more food available here than in other habitat types. Deer are provided with both cover and food in the form of understory shrub species. Predators, including weasels, skunks, and possibly marten and fisher, bobcat, and mountain lion, can hunt effectively in these areas. More species of bats forage over forest areas than most other habitat types.

Dune areas are used or visited by relatively few mammals, nine to thirteen species in the study area. Deer occasionally forage in more densely vegetated portions of the dunes. Deer mice, meadow mice, gophers, ground squirrels, rabbits and hares occur there, and some of their predators, including weasels, fox, coyote, and bobcat, may hunt there on occasion. Raccoon, porcupine and the striped skunk are known to visit and perhaps even live in such areas.

Water habitats support various numbers of mammals. Rivers and streams are utilized to some degree by all mammals living in adjacent habitats; all species living in the study area require free water to drink. Some species are very water oriented, the river otter to a large degree, and weasels, mink, and raccoons to a lesser

extent. Humboldt Bay is utilized by harbor seals and is visited by sea lions, harbor porpoises and possibly false killer whales. Most of the porpoises and whales utilizing ocean waters in the vicinity of Humboldt Bay do not ordinarily enter the bay.

Salt marsh and brackish marsh habitats are probably not used extensively by mammals in the study area. Such areas may be visited by deer, raccoon, skunk, and weasel living in adjacent areas, and bats may forage over the marsh in pursuit of insects. The harvest mouse may live in brackish marsh areas.

Fresh-water marsh and swamp may support a number of species of small rodents and insectivores, as well as predators on these and co-occurring insects. Raccoon, skunk, weasel, coyote, and possibly mink may be found here. Deer certainly forage in these areas and many, if not most, species of bats forage over these habitats which are very productive of flying insects.

Mudflats are used as hauling areas by the harbor seal and are critical to this species during the pupping season. Hauling areas are noted on Plate 12.

Jetties are unimportant to any mammal species living in the area. They may be used by rats and occasionally by raccoons or other species which scavenge on dead fish or invertebrates stranded on the rocks. It has been suggested that mink or otter may use jetties occasionally but this is considered unlikely.

Rare and Endangered Species

Six species of mammals have been designated by federal authorities as rare or endangered. These six species are marine mammals that may occur in the open ocean along the northern California shoreline. The Right, Hump-backed, Blue, Sei, and Sperm whales are listed as endangered, and the Grey whale is described as rare.







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KNOWN WILDLIFE AREAS

PLATE NO 12 NORTH

LEGEND

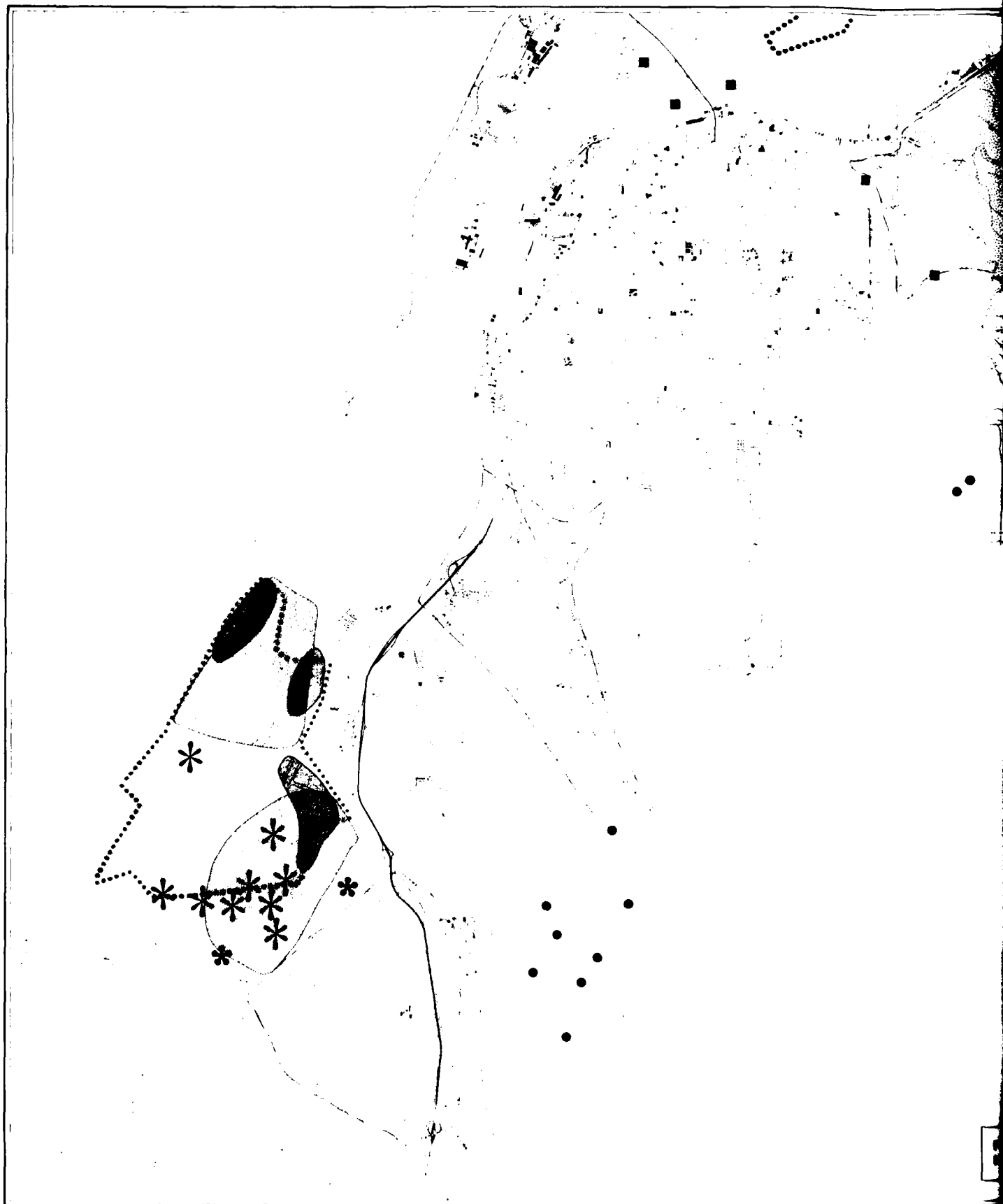
-  Bufflehead Feeding Areas (e)
-  Duck Nesting Areas (c)
-  Great Egret Roosts (f)
-  Harbor Seal Haulouts (a)
-  Wilson's Snipe (d)
-  Brant Feeding Areas



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source Loughlin 1974 (a)
Ueoka 1974 (b)
Wheeler & Harris 1970 (c)
White 1963 (d)
Wiemeyer 1967 (e)
Yull 1972 (f)





KNOWN WILDLIFE AREAS

PLATE NO 12 SOUTH

LEGEND

- Osprey Nesting Sites (d)
- ▣ Osprey Hunting Areas (d)
- Bufflehead Feeding Areas (f)
- Duck Nesting Areas (e)
- * Favored Pintail Feeding Areas (a)
- Great Egret Roosts (g)
- * Seal Haulouts (b) (c)
- Brant Feeding Areas



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Densen 1961 (a)
Loughlin 1974 (b)
Rosenthal 1968 (c)
Ueoka 1974 (d)
Wheeler & Harris 1970 (e)
Wiemeyer 1967 (f)
Yull 1977 (g)

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N. BIRDS

About 266 species of birds probably use the resources of the Humboldt Bay area as residents, summer or winter visitors, migrants or transients. These species may be grouped into the following five categories on the basis of similarities in taxonomic relationship and utilization of food and habitat resources: Terrestrial game birds, waterfowl, shorebirds, wading birds, raptors, and other bird species. For the majority of species, sufficient natural history information is available to permit identification of the major habitat types of importance to each. The compilation of such information most specific to the Humboldt Bay wetlands and surrounding areas is that of Yocom and Harris (1975). In addition, considerably more extensive data base is available for a relatively small proportion of the bird species in the form of Master's theses from Humboldt State University. Information pertinent to habitat utilization is summarized in Table E-5 (Appendix E) and discussed along with data on food habits, reproduction and abundance in the following sections.

Terrestrial Game Birds

The principal upland game species in the Humboldt Bay area are the band-tailed pigeon and the Wilson snipe. Both of these have been studied in the area of concern.

Wilson snipe are members of the shorebird group (Family Scolapacidae) but are normally found in inland areas in wet meadows and marshes, or along streams. They breed during the summer in regions to the north and some winter in the Humboldt Bay region.

Wintering populations of snipe were studied by White (1963) in two areas in Humboldt Bay (Plate 12). Occurrence of snipe in salt marsh habitat peaked in November and late February or March in both years of the study. Pasture habitats appeared to be used more irregularly over three years but, in general, supported a larger portion of the over-wintering population. White and Harris (1966) analyzed this differential use of habitats (Appendix E, Table E-5) and showed that salt marsh habitats were most important to the snipe with upland pasture and plowed areas being less important, although available in greater area, and lowland pasture being occasionally important. Food items taken by snipe included both plant and animal material with plant fibers, insects, and seeds appearing most frequently in stomach samples.

Band-tailed pigeon. This species is common as a migrant, summer visitant and breeder in mixed evergreen forests and agricultural land (Yocom and Harris, 1975). Analysis of the diets of individuals taken from all parts of California indicates that cultivated fruits and grains and acorns are important foods during the spring and early summer months, portions of various shrub species become

important in the late summer and acorns of various oak species again predominate during the winter (Smith, 1968). Pigeons begin to arrive in the Humboldt area in March and set up nesting territories along the drainages of rivers and streams running into the Bay. Nests are constructed in both live trees and dead snags of redwood, douglas fir, sitka spruce, and alder, with maple, red cedar and hemlock being used occasionally.

Waterfowl

Waterfowl species and some of the most socio-economically important birds in the study area because of their hunting and aesthetic value. Consequently, members of this group have been studied more thoroughly than most other vertebrates in the area. Interest in the hunting of waterfowl has prompted the California Department of Fish and Game to conduct periodic censuses of populations on Humboldt Bay. Table VI-12 shows seasonal trends in numbers of 33 species of "water-associated" birds including about 20 species of waterfowl (Monroe, 1973). The American widgeon is consistently the most abundant during the hunting season (October-December) with the scaup, scoter, pintail, redhead, mallard and teal also present in good numbers throughout this period. Bufflehead are also present during the hunting season, but in lower numbers. Black brant pass through in fall and spring and a special hunting season occurs in January and February before peak spring populations. Some feeding and resting areas favored by scaup, bufflehead, redhead, widgeon, and pintail have been mapped by Densen (1961) and are shown in Plate 12.

Diets of eleven species of waterfowl have been described on the basis of crop and gizzard analysis by Yocom and Keller (1961). Monroe (1973) summarized these data assembled by Yocom and Keller for four species of puddle ducks (pintail, mallard, widgeon, green-winged teal) and six species of diving ducks (canvas-back, lesser scaup, greater scaup, bufflehead, scoter, ruddy duck (Tables VI-13 and 14). Plant foods were shown to be more important, in general to the puddle ducks with clams and gastropods being the principal animal foods. With the exception of the Ruddy duck, diving ducks were far more dependent on animal foods.

Nesting and production of young by mallard and cinnamon teal was investigated in some detail by Wheeler and Harris (1970). Areas identified as important to duck production are shown in Plate 12. Vegetation features of nesting areas were also described. Mallards appear to prefer tall stands of hairgrass to other and shorter types of cover, while cinnamon teal nest more frequently in short vegetation showing essentially no preference for a particular species of vegetation.

Autecological (single-species) studies have been conducted for bufflehead, Aleutian Canada geese, black brant, double-crested cormorant, and American merganser.

Table VI-12

WATER ASSOCIATED BIRD CENSUS
Average Monthly Populations 1967-68-69-70*

Species	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Average July-Aug.	Average Sept-Apr.	Monthly Average All Yr.	Total Annual Bird Days
Black brant	0	1	130	4	1,093	19	6	795	12,039	21,208	4,071	4	1,019	4,412	3,198	1,167,470
SUBTOTAL	0	1	130	4	1,093	19	6	795	12,039	21,208	4,071	4	1,019	4,412	3,198	1,167,470
Mallard	53	154	387	785	172	477	293	484	628	219	387	33	157	431	339	
Blue-winged teal	9	2,019	4,976	3,491	1,641	1,643	2,940	2,356	1,157	303	0	3	508	2,323	1,718	
Widgeon	2	17	20	4,027	8,903	11,581	11,770	10,338	3,257	1,571	17	2	10	6,438	4,295	
Goldeneye	0	0	19	0	32	63	1	1	13	8	0	0	0	17	11	
Green-winged teal	3	83	33	204	295	705	135	1,065	554	1,522	7	0	22	564	303	
Blue-winged teal	2	8	128	0	0	0	0	0	2	0	0	22	10	17	15	
Goldeneye	3	0	0	0	0	493	560	807	1,379	842	2	0	1	600	400	
SUBTOTAL	72	2,281	5,591	9,021	11,163	14,962	15,699	15,131	6,990	4,515	413	60	708	10,390	7,161	2,613,765
Coot	7	119	9	1,019	2,510	3,217	1,805	5,629	5,842	1,377	199	16	85	2,076	1,812	
Redhead	0	0	0	2	34	256	195	952	80	40	10	0	3	195	131	
Canada goose	0	0	0	0	133	208	567	795	236	141	3	0	1	261	174	
Ring-necked	0	0	0	0	0	0	20	0	0	0	0	0	0	3	2	
Goldeneye	0	0	0	0	0	0	72	0	0	2	0	0	0	9	6	
Bufflehead	0	0	0	0	155	607	543	2,093	254	354	5	0	2	501	335	
Ruddy	3	8	38	9	154	222	1,230	1,893	110	533	2	2	4	524	350	
Scoter	300	870	635	1,792	6,093	2,535	5,302	4,505	2,699	2,709	1,649	447	817	3,204	2,461	
SUBTOTAL	310	1,000	682	2,830	9,079	7,045	9,734	15,867	9,221	5,156	1,868	465	912	7,453	5,272	1,923,915
Merganser	0	0	0	1	164	8	80	146	71	83	1	0	0	69	46	
Unidentified	7	0	3	23	371	616	10	430	223	497	134	1	1	272	193	
Swans	0	0	0	0	0	0	0	0	0	0	0	0	0	8	6	
SUBTOTAL	7	0	3	24	535	624	90	643	294	580	135	1	36	349	245	89,425
Goosander	3,625	2,577	5,250	3,898	8,842	1,710	1,680	1,558	2,226	3,605	332	341	1,719	2,972	2,554	
Curlew	224	427	322	22	14	0	0	0	2	212	38	17	177	72	107	
Willet	874	1,065	2,773	2,057	1,804	2,207	1,440	2,069	1,494	2,547	164	169	551	2,023	1,552	
Avocet	0	0	34	85	53	96	0	222	3	4	0	0	0	62	41	
Killdeer	0	0	0	6	0	90	400	250	29	0	1	2	1	97	65	
Other shorebirds	1,857	8,332	20,545	16,665	37,291	17,430	14,095	20,613	11,816	29,728	715	259	3,391	21,033	15,112	
SUBTOTAL	8,510	12,401	28,924	22,728	43,084	21,533	17,615	24,712	15,570	36,096	1,250	788	5,739	26,279	19,431	7,092,315
Coots	17	9	39	507	594	1,300	1,480	1,752	585	1,570	30	8	16	978	658	
SUBTOTAL	17	9	39	507	594	1,300	1,480	1,752	585	1,570	30	8	16	978	658	240,170
Blue heron	901	122	108	0	47	27	89	180	104	160	283	245	238	98	145	
Night heron	72	17	0	0	0	0	3	50	0	7	35	69	48	11	23	
Great egret	789	507	217	99	70	29	70	333	160	333	452	539	572	133	279	
SUBTOTAL	1,162	646	326	187	117	56	162	388	264	508	770	853	850	242	447	163,155
Arctic skua	15	2	46	541	1,133	618	1,151	1,107	463	380	58	20	24	680	461	
Loon	15	0	10	6	41	10	50	39	37	28	27	6	11	27	22	
Black-throated	297	15	457	470	132	83	136	230	230	200	301	268	305	239	254	
Booby	5	14	14	33	21	0	0	0	0	0	1	0	5	27	18	
SUBTOTAL	340	308	640	795	1,319	711	1,337	1,376	730	608	387	294	345	961	755	275,575
Loons	1,000	10,000	10,000	10,000	86,934	46,000	46,133	60,594	45,693	70,271	8,924	2,473	9,633	51,004	37,160	13,505,590

* taken from Monroe, 1973

Table VI-13

Food of Four Species of Puddle Ducks, Humboldt Bay *
 (Adapted from Yocom and Keller, 1961)
 (Food Items Consumed Shown by Percent of Volume)

Plant Food	(49) Pintail	(24) Mallard	(140) Widgeon	(50) Green-winged Teal
Barley, <i>Hordeum vulgare</i>	25.1	49.6	-	-
Pondweed, <i>Potamogeton</i> sp.	.1	13.9	.3	2.4
Alkali bulrush, <i>Scirpus robustus</i>	14.8	3.9	Trace	7.6
Spikerush, <i>Eleocharis macrostachya</i>	4.8	5.8	3.5	15.0
Widgeon grass, <i>Ruppia maritima</i>	4.7	-	-	.3
Eel grass, <i>Zostera marina</i>	.4	Trace	81.0	-
Buttercup, <i>Ranunculus</i> sp.	Trace	1.8	1.4	8.5
Saltgrass, <i>Distichlis spicata</i>	.8	-	Trace	.3
Wheat, <i>Triticum aestivum</i>	-	-	-	5.2
Clover leafage, <i>Trifolium</i> sp.	-	-	6.0	-
Other plants	<u>36.0</u>	<u>21.4</u>	<u>8.9</u>	<u>26.3</u>
Total	86.7	96.4	99.7	65.6
Animal Food				
Clams, <i>Pelecypoda</i>	11.2	.9	-	-
Gastropods, <i>Gastropoda</i>	1.3	.9	Trace	33.6
Mollusks, <i>Mollusca</i>	.8	-	-	.3
Arthropod, <i>Arthropoda</i>	Trace	-	-	-
Insects, <i>Insecta</i>	-	1.8	.3	-
Other animal matter	<u>-</u>	<u>-</u>	<u>Trace</u>	<u>.5</u>
Total	13.3	3.6	.3	34.4

*Taken from Monroe, 1973

Table VI-14

Food of Six Species of Diving Ducks, Humboldt Bay *

(Adapted from Yocom and Keller, 1961)

(Food Items Consumed Shown by Percent of Volume)

Plant Food	(17) Canvas- back	(13) Lesser Scaup	(20) Greater Scaup	(22) Buffle- head	(17) Scoter	(21) Ruddy
Pondweed, <i>Potamogeton</i> sp.	15.7	.7	-	3.6	-	23.1
Widgeon grass, <i>Ruppia maritima</i>	2.6	Trace	-	1.9	-	68.1
Eel grass, <i>Zostera marina</i>	Trace	-	4.4	-	-	1.1
Alkali bulrush, <i>Scirpus robustus</i>	-	.1	Trace	5.1	-	1.1
Wheat, <i>Triticum aestivum</i>	-	4.6	-	-	-	-
Saltgrass, <i>Distichlis spicata</i>	-	.1	-	-	-	-
Spikerush, <i>Eleocharis macrostachya</i>	-	.1	-	Trace	-	1.1
Other plants	<u>-</u>	<u>35.2</u>	<u>.1</u>	<u>0.7</u>	<u>Trace</u>	<u>Trace</u>
Total	18.3	40.8	4.5	11.3	Trace	94.5
Animal Food						
Clams, <i>Pelecypoda</i>	81.7	45.5	42.8	17.5	48.8	-
Mollusks, <i>Mollusca</i> (unidentified)	-	9.1	2.9	-	-	-
Crustaceans, <i>Crustacea</i>	-	4.6	-	29.8	6.6	5.5
Gastropods, <i>Gastropoda</i>	-	Trace	49.7	15.5	30.3	-
Insects, <i>Insecta</i>	-	-	-	25.7	-	-
Oyster, <i>Ostra</i> sp.	-	-	-	-	14.1	-
Other animal food	<u>-</u>	<u>-</u>	<u>.1</u>	<u>.2</u>	<u>.2</u>	<u>-</u>
Total	81.7	59.2	95.5	88.7	100.0	5.5

*Taken from Monroe, 1973

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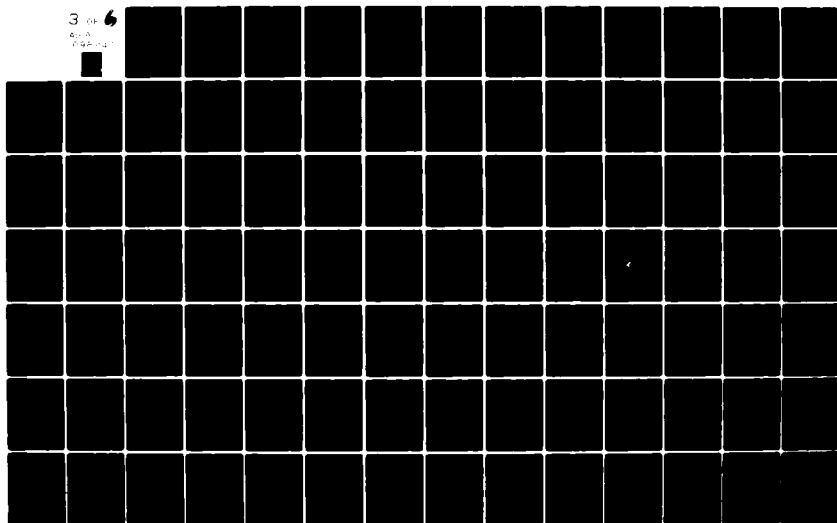
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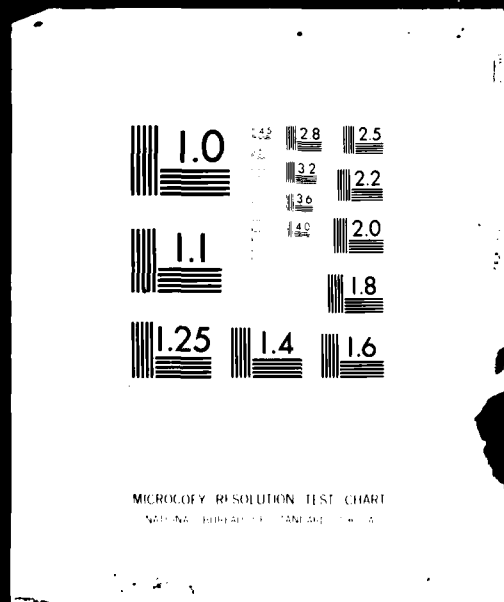
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Bufflehead food habits were examined in individuals collected from different wetland habitats in the study area by Wiemeyer (1967). Feeding and resting areas on Humboldt Bay are shown on Plate 12. Wiemeyer (1967) contrasted the diets of birds taken from Arcata Bay, South Bay and several sloughs and ditches in the vicinity. Fish and lamellibranchs occurred much more frequently in samples from Arcata Bay than South Bay, but crustacea were more abundant in the latter. The amount of stored fat and the relative frequency of parasites both indicated that individuals feeding on the bay were in better condition than those found on sloughs and ditches.

Aleutian Canada geese (*Branta canadensis leucopareis*), an endangered species according to federal regulations, have been reported in the Humboldt Bay area. A recent study of these geese by Woolington, et al. (1979), discusses the wintering and migration distribution of these birds. Although the southward migration route to Central California of these geese is not well known, some birds probably fly south along the West Coast to at least the mouth of the Eel River before heading inland. Between January and March, during their northward migration, several confirmed sightings of Aleutian Canada geese are reported for the Humboldt Bay area as they head towards the spring staging area at Crescent City. While most birds fly over the area in migration, some flocks are known to alight. In January 1975, a flock of 30 were seen grazing near the mouth of the Eel River. Management for the restoration of the once-declining population includes hunting closures in known wintering and migration areas. Because of their tendency for site-specificity in annual patterns, such localized management options are practical. Removal of introduced predators on Aleutian Island breeding grounds has helped enhance reproductive success.

Black brant occurs primarily as a migrant in the study area, and as such is far more abundant during the spring migration than in the fall. Most information on the occurrence of this species is due to Murrell (1962), Denson and Murrell (1962), and Henry (1980). Inventories of wintering populations of this species in the 1950's revealed a disturbing decline in numbers and promoted studies of distribution and status of over-wintering groups by state and federal wildlife agencies. Normally, very few brant overwinter in the Humboldt Bay area, but in the winter of 1951-52 flocks of 20,000-25,000 birds fed daily in pastures at the McBride Ranch near Beatrice Flats [presumably because of depletion of eelgrass, the preferred food, in Humboldt Bay (Yocom and Harris, 1975)] and in the winter of 1957 some 3,500 birds were censused on the Bay. There are several indications that the study area may be critical to the survival of this species. Humboldt Bay is located halfway between two large areas of suitable habitat, Mexico to the south and Washington to the north. Approximately 88% of the Pacific brant population winters in Mexico. In some years (e.g., 1961) huge concentrations of brant gather on feeding areas around the Bay during the northerly migration between early March and late May. Estimates that 25% of the total brant population pause

in Humboldt Bay during northward spring migration may be a minimum figure because constant ingress and egress of migrants in spring make a true estimation difficult (Henry, 1980). Migratory and breeding success is undoubtedly heavily dependent on this "refueling" stop. Henry (1980) reports a decline in brant population counts in Humboldt Bay during the span from 1975 to 1978 in a period when the overall Pacific brant population was increasing, presumably due to continual intense human activity around the Bay. Fairly large shifts from year to year in age structures of the population, indicated by the representation of age classes of brant bagged on Humboldt Bay suggest that reproductive success on breeding grounds in Canada is highly variable (Denson and Murrell, 1962). Consequently, the quality and dependability of resource areas used in migration may have a disproportionate impact on the population as a whole. Studies of the food habits of brant on Humboldt Bay summarized by Murrell (1962) show that eelgrass is by far the most preferred food item. Important brant feeding habitat is shown to roughly align with eelgrass beds in the Bay (Plate 12).

Double-crested cormorant. A breeding colony of this species, located on the abandoned remains of the old Arcata wharves, is thought to be the largest in California and the second largest on the Pacific Coast (Ayers, 1975). Declines in populations of this species all over North America have been attributed in part to effects of DDT and its metabolites on egg shell thickness. Ayers examined colony size, breeding chronology, and reproductive performance in the Humboldt population, and compared his findings with those of other studies. The number of fledglings successfully raised per nest averaged 1.0 to 1.1, about the same figure found for a colony in Maine and about half the fledgling rate found in colonies in British Columbia and Alberta. Taking adult mortality into account, this rate of production of young cannot promise maintenance of the population in the study area.

American Merganser occurs in estuarine portions of the study area foraging in flocks averaging 2.7 individuals in the mating season, 8.2 in the brood season, and occasionally becoming very large during the winter (Foreman, 1975). Studies by Foreman showed the birds to be most active during morning hours, feeding by diving and head dipping. Birds took off and landed only on water, but loafed on rock, gravel, or sandy beach areas. In estuarine areas, the sex ratio strongly favored males (70-90 percent); males challenged paired birds from February through April. One nest was discovered in a Douglas fir about 100 feet above the ground. Most nesting probably occurs in inland areas where brood size has been observed to average 8.2 chicks and chick mortality is estimated to be about 20-40 percent in the first three weeks of life.

Shorebirds

Species in this group, including plovers, avocets, phalaropes, and shorebirds proper, are among the most numerous and visible

in the study area. Shorebirds feed extensively on invertebrates, usually extracting them from soil or sandy substrates by various modes of pecking and probing. Feeding activities in the study area occur primarily on beaches, sand flats and mudflats and pastures, and occasionally in marsh or open water. None of the species in this group breed in this region; most are migrants, and some overwinter in the area. The importance of the study area to shorebird species is reflected in the comparative census data shown in Table VI-15. The Humboldt Bay area supports larger concentrations of these species than the other areas censused along the California coast (Monroe, 1973), and undoubtedly provides an extremely important and strategically located feeding stop for migrants.

Some information on food preferences and the relationship of habitat utilization to food item abundance is available for members of the shorebird group. Holmberg (1975) examined food in the digestive tracts of seven species of shorebirds collected (and presumably feeding) in two different habitat types, mudflat and pasture. He compared utilization of various food items to their abundance in the habitat. Least sandpipers had taken molluscs crustacea, insects, and vegetable matter most frequently in mudflat areas but only insects and vegetable matter in pastures. Western sandpipers fed on polychaetes in addition to the arthropods, molluscs and vegetation in mudflat areas; in birds from pasture areas the food was unidentifiable. Dunlins were sampled only from mudflats where they consumed an array of plant and animal foods similar to those of sandpipers. Dowitchers appear to be more specialized feeders in mudflat areas, taking mostly polychaetes and pelecypods, including several species of the latter which apparently burrow too deeply to be accessible to shorter-billed species. The diet of the marbled godwit, a species possessed of a very long, sturdy bill effective in digging, also emphasizes polychaetes and gastropod and pelecypod molluscs obtained from deeper in the mudflat. Willets are generalists, both in terms of food taken and style of foraging; in mudflat areas, their diet was dominated by shallow mud and surface-dwelling arthropods and pelecypod molluscs, and included polychaetes and some fish. Black bellied plovers have relatively short bills and obtain most food from at or near the surface of the substrate; gut analysis of birds from mudflat areas revealed certain polychaetes, insects, and molluscs to be most abundant in the diet.

A species not commonly seen in the Humboldt Bay, but which infrequently feeds on rocky areas of the outer coast, is the black oystercatcher. Helbing (1977) reports food items taken by this species of which the California mussel is the most important. Helbing documented the composition of the diet of oystercatcher chicks from an offshore nesting site and noted the selective feeding on mussels and limpets.

Table VI-15

COMPARATIVE MONTHLY COUNTS OF SHOREBIRDS CENSUSED
FROM COASTAL WETLANDS*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mth. Avg.
Bolinas Lagoon- 1968	-	-	-	-	-	-	-	4,505	5,575	<u>12,850</u>	10,899	-	8,457
Tomasales Bay <u>1/</u>	9,298	-	8,488	-	2,484	-	-	-	2,467	4,859	<u>12,220</u>	-	6,636
1970	6,911	5,736	14,051	<u>24,165</u>	-	-	-	-	-	-	-	-	12,715
South San Diego Bay <u>2/</u>	1970	5,766	8,618	7,614	<u>13,678</u>	466	889	3,699	8,653	8,608	9,750	-	6,774
Elkhorn Slough <u>2/</u>	1967	6,244	4,228	7,718	17,067	341	300	3,915	6,127	3,753	17,457	16,826	8,821
1968	10,869	<u>11,191</u>	9,010	9,018	504	836	-	-	-	-	-	-	6,905
Humboldt Bay <u>1/</u>	1967	-	-	-	-	-	-	-	-	22,986	<u>39,208</u>	14,969	25,954
1968	-	23,681	18,139	38,844	1,494	956	4,212	20,574	<u>50,917</u>	10,255	41,306	-	21,038
1969	17,615	-	25,528	34,393	670	656	6,995	10,629	18,683	33,940	<u>47,932</u>	30,097	20,650
1970	-	25,962	7,045	<u>35,051</u>	1,584	754	5,325	5,998	17,172	-	-	-	12,362

1/ Aerial census2/ On foot

Highest monthly counts are underlined.

*Taken from Monroe, 1973

Wading Birds

Hérons, egrets and bitterns are wading birds which regularly occur in the study area. The white-faced ibis and the American flamingo have been represented by unusual accidental occurrences. Members of this group hunt for fish and invertebrates while standing or walking in water submerging only the legs; some species are known to prey on small mammals and insects in open fields. Herons and egrets are of special interest in the study area since most of the species involved are residents that roost and breed on particular sites year after year. Various aspects of the ecology of these species have been examined by Master's thesis research conducted in the Humboldt Bay area.

Habitat use and feeding ecology of the great egret were studied by Schlorff (1978). Individuals of this species forage singly or in small groups. Schlorff (1978) found that group size was largest in mudflat and salt marsh situations, and that these habitats and pastures showed the largest numbers of birds in both wet and dry seasons. While birds appeared less frequently along tide channels or on highway margins and median strips and were usually alone under these circumstances, they were almost always actively feeding when in these habitats. Birds in salt marsh, on the other hand, were actively feeding a relatively small proportion of the time; this habitat may be the most important refuge for resting birds during the daytime.

Fish species known or suspected to be eaten by the great egret are listed in Table VI-16; data on the relative importance of these species in the diet is not available. Schlorff (1978) attempted to determine the predatory impact of the great egret on fish populations as a whole and on small mammals taken on terrestrial feeding sites. He found that these birds spent 30 percent of the year feeding in terrestrial habitats, and that although small mammals made up only one percent of their overall diet they provided 15 percent of biomass consumed and 16 percent of energy consumed on an annual basis. This was because the average small mammal captured had considerably more biomass than the average fish captured. Thus, while hunting on terrestrial foraging sites is less efficient in terms of strike success and capture rate, the energy intake obtained makes such areas an energetically viable alternative to aquatic hunting areas, especially during the wet season. A comparison of predatory efficiency in the great egret and other wading birds, raptors and seabirds, shows the great egret to be a more efficacious predator than all other species examined with the exception of the cattle egret.

Aspects of the breeding ecology of three species of wading birds, the great egret, great blue heron, and black-crowned night heron, were described by Ives (1972,1973). The study concentrated on the rookery located on Indian Island. Great egrets roosting on this island tended to prefer feeding in areas in and around the North Bay and nested more frequently on the east end of the island. This

Table VI-16

Humboldt Bay fishes known or suspected to be part of the great egret diet. Ecological information from otter trawls made by Samuelson (1973) and Sopher (1969).*

<u>Species</u>	<u>Size Range (cm)</u>	<u>Remarks</u>
Shiner Surfperch* (<u>Cymatogaster aggregata</u>)	3.8-19.0	Spawn in May; June-Dec. fish smaller than 85mm dominate.
English Sole* (<u>Parophrys vetulus</u>)	11.0-11.5	Juv. common on Mudflat and Tide Channel; avail. all year.
Speckled Sanddab* (<u>Citharichthys stigmaeus</u>)	2.6-19.2	Avail. all year; spawn Sept.-Dec.; common on Mudflat and Tide Channel.
Longfin Smelt (<u>Spirinchus thaleichthys</u>)	5.0-15.0	
Pacific Staghorn Sculpin* (<u>Leptocottus armatus</u>)	2.8-26.1	Common on Mudflat and Tide Channel; most abundant Jan.-Feb.
White Seaperch (<u>Phanerodon furcatus</u>)	5.3-30.3	Avail. all year; peak in June, July and Sept.
Walleye Surfperch (<u>Hyperprosopon argenteum</u>)	5.5-26.2	Common on Mudflat; most abundant June and July.
Pile Perch (<u>Damalichthys vacca</u>)	7.4-37.5	Juv. common on Mudflat; size at birth 76-86 mm TL.
Buffalo Sculpin (<u>Enophrys bison</u>)	4.1-19.0	Common in Tide Channel.
Starry Flounder* (<u>Platichthys stellatus</u>)	4.0-58.4	Avail. all year; peak in June, July and Jan. Young of yr. 40-60 mm TL. dominate June-Aug. Common in Tide Channel.
Northern Anchovy* (<u>Engraulis mordax</u>)	3.0-11.1	April, Aug. and Sept. size 35-45 dominate.

*Taken from Schlorff, 1978.

rookery is the most northerly great egret colony along the Pacific Coast. Great blue herons feed more frequently in salt marsh areas on the island and showed a slight preference for nesting in the middle and western portions of the island. All three species showed seasonal use of the rookery such that no two species were present in maximal numbers at one time. The great egret was present in numbers from March through September and maximally represented in August and September. The great blue heron was most abundant in February and declined in numbers through July. The black-crowned night heron was present in March through May, but never in numbers approaching those of the other two species.

Ives (1973) described the nesting colony of the three species discussed above in some detail. Nests were generally located in tall eucalyptus and cypress trees with up to four nests per tree in the tallest trees of both species. Cypress trees are more abundant on the island and therefore support more nests. Numbers of active nests utilized by great egrets, great blue herons, and black-crowned night herons were recorded from 1966 to 1972; year-to-year variation is great, but great egrets generally are better represented in the rookery than the other two species. The nesting season chronology of the three species is initially staggered, but fledging of young occurs at about the same time, suggesting that climatic factors or seasonal food abundance are important to fledging success.

Analysis of eggshell thickness (Ives, 1973) indicated that Indian Island populations may be less subject to the effects of pesticide residues than those at other rookeries in the state. Eggshell thinning is detectable in all populations examined over about a 25 year period; but thinning in the Indian Island population is lower for hatched eggs and no greater for broken eggs than in other populations.

Habitat use by great egrets was studied by Yull (1972) in areas bordering the southern part of Arcata (North) Bay. Roosting sites are identified on Plate 12. Seasonal patterns appear in the relative importance of four habitat types surveyed but are not easily evaluated on the basis of the data provided.

Yull (1972) observed nesting and raising of young by great egrets on Indian Island in two years, and was able to estimate reproductive performance in this rookery and make comparisons with other rookeries in which reproductive performance was measured in a similar way. The results indicate that the Indian Island egrets have higher rates of both nesting success and fledging success than those observed at Bolinas and San Joaquin. These data, along with the egg shell thinning data, suggest that the Indian Island population is, if not unaffected by human influences, probably the one least so affected in California.

Raptors

Twelve species of raptors potentially occur in the study area. Two of these, the bald eagle and the peregrine falcon, are considered endangered under the Endangered Species Act of 1973 (PL 93-205). The peregrine is thought to breed in the vicinity of Humboldt Bay but no recent nesting records are provided by Yocom and Harris (1975). This species hunts in dune and intertidal flat habitat types, and at the Arcata oxidation ponds. The bald eagle occurs around river estuaries but is not known to breed in the coastal area. Three other species have been investigated in some detail in the study area: osprey, kestrel, and white-tailed kite.

Osprey. This species is common in summer in the study area, occurring over and around the Bay and rivers entering the Bay. Principal hunting areas over the Bay, identified by Ueoka (1974), are shown in Plate 12. At least eight species of fish are known or strongly suspected to be taken by osprey from the Bay (striped, white and shiner surfperch, staghorn sculpin, pacific herring, northern anchovy, topsheet, and jacksheet). The relative numbers of these species taken at different stages of the nesting cycle have been documented (ueoka, 1974); surfperch was the most important of those identifiable (1974).

The locations of a large number of osprey nests have been mapped in the study area (French, 1972, and cited by Ueoka, 1974). Nests are located along the Elk River and Salmon and Freshwater Creeks, and on Humboldt Hill (Plate 12) and are usually constructed in the tops of dead snags on redwood and sitka spruce. French calculated fledgling productivity on the basis of information on several areas in northwestern California. He identified 19 nests in 1971 and 33 nests in 1972 in the vicinity of the study area and determined that nesting attempts here were more successful in fledging larger broods than attempts made along major streams elsewhere in the county.

American Kestrel is more common in the study area in winter and during migration than in summer (Yocom and Harris, 1975) and is most frequently seen in agricultural areas, grassland, shrub and cut-over habitats. It tolerates light urbanization moderately well, and is often seen hunting from the tops or wires of telephone and electric lines.

Observations of feeding by a single male kestrel by Berdan (1976) permitted identification of some prey items utilized in the study area. Various invertebrates, predominately gryllids, and several kinds of vertebrates, including voles and mice, frogs, and salamanders were identified. Callopy (1975) quantified the frequency, biomass, and energy of vertebrate and invertebrate prey taken by kestrels over two seasons, on the basis of somewhat more extensive data than Berdans (1976). He then calculated the predatory efficiency of the kestrel in his study area near Arcata and presented the results together with those of other studies quantifying success relative to kind of prey, mode of hunting, etc. Small mammals were the most important prey, energetically, in one year and invertebrates were more important in another.

White-Tailed Kite is relatively uncommon in the study area, and is most frequently seen in agricultural and grassland areas. Individuals or pairs are occasionally seen hovering and "kiteing" (dropping slowly with wings held at a fixed angle), usually over areas of moderate to dense cover where rodents are present. Over 30 kites were seen roosting together in the Eel River bottoms (cited by Yocum and Harris, 1975, observation by Miller and Gerstenberg).

Bamman (1975) investigated patterns of habitat use and wintertime predatory efficiency in this species in the Arcata Bottom. He mapped the availability of 17 habitat types in the area and determined that the six types in which kites hunted constituted about 62 percent of the total area. Of these six habitat types, kites strongly preferred to hunt in tall rank grass, spending about 73 percent of their time hunting over such areas which accounted for only a little over one percent of the total area. The majority (73 percent) of prey captured were obtained from such areas.

Other Bird Species

Several taxonomic groups of birds have received essentially no attention from biologists in the study area. These include owls, hummingbirds, kingfishers, woodpeckers, and perching birds. The feeding ecology of the taxa most important in the study area is summarized below with respect to certain features common to the species involved.

Nocturnal species active in the study area include eleven species of owls and nighthawks. Members of both groups are carnivorous. Owls prey principally on small mammals, but the smaller species take some insects. The burrowing owl is active during the day. The nighthawks (poor-will and common nighthawk) are insect feeders that forage most intensively at or just after dusk.

Insectivores. Several quite distinct groups of birds are brought under this heading. Swifts are fast fliers and forage well above the treetops for flying insects. Swallows are somewhat more erratic fliers which feed lower over treetops and bodies of water. Flycatchers feed on flying insects; some species fly about after their prey, others sally forth from the tops of tall trees to pursue nearby prey, and still others fly very short distances within or near the canopy of trees to capture insect prey.

Other insectivorous birds specialize on sedentary prey. Woodpeckers, sapsuckers, and flickers extract insect larvae from bark and dead wood in trees. The common flicker is atypical in that it also forages for insects on the ground. Warblers and vireos forage for insects in the foliage and branches of trees. Other species which feed on insects in a variety of ways in wide array of micro habitat situations include wrens, thrushes, blackbirds, and tanagers. Some of the species in these groups feed on vegetable material as well. Titmice, chickadees, and kinglets are omnivorous to some extent.

Granivores and Frugivores seed-and-fruit-eating species are found in several taxonomic groups, including the waxwings, the omnivorous titmice and chickadees, and the finches, but predominately in the latter. Thirty species of finches potentially occur at times on the study area; most of these feed primarily on native grains and berries but will readily exploit cultivated crops or the fruits of ornamental vegetation when available.

Habitat Use by Birds

Some general trends in habitat use in the study area by bird species can be drawn from the species totals listed by habitat type at the end of Table E-5 (Appendix E). These numbers must be considered crude estimates of the total number of species utilizing a given habitat type and may be underestimates because of their reliance on reported sightings and the conservative application of intuition.

Urban areas are utilized over the course of the year by some 30 species of birds. Gulls are drawn to dumps and refuse heaps. Rock doves and morning doves thrive among buildings, streets and parks. Hummingbirds exploit the nectar resources provided by flower gardens and ornamental shrubbery. Various insect and seed-eating species that are somewhat accustomed to human activity may occur and actually be attracted by feeders.

Agricultural areas in the Humboldt Bay vicinity including srop and pasture land are utilized by some 71 species, essentially as many species as are found in any other habitat type. In Hoff's (1979) comprehensive study of bird use of agricultural lands, 127 species were recorded. However, the habitats covered in his survey included marshes and sloughs. Pasturelands receive heavy use by feeding and resting shorebirds from late fall to early spring. Waterfowl use occurred primarily during rainy periods when pastures remain wet. Pastures appear to be a vital part of the daily feeding habit for wading birds. During fall and winter months, raptor use of pastures for foraging is common as pastures provide attractive habitat for prey species (Hoff, 1979). Swallows and swifts forage over such areas, particularly when water or marshy conditions contribute large quantities of emerging insects. Many species forage in these areas when preferred food in unaltered habitats is in short supply. Only those species which can utilize the remnants of undisturbed habitat or fence rows for roosting or nesting, principally perching birds, remain in agricultural areas when not feeding.

Grassland areas contribute to the support of more species in the study area than any other habitat type. As with agricultural areas, the level of usage involves activities by a variety of bird groups. Shorebirds, wading birds, ducks and geese feed on arthropods and vegetable material in these areas. Swallows and swifts may

appear, particularly over the wetter areas. Seed-eating species harvest the products of grasses and forbs. Gulls may feed occasionally in these areas as well. Hawks, owls and egrets take small animals supported by such habitat. Portions of grassland that are adjacent to shrub habitats or woodlands, or contain elements of these habitat types, receive the greatest use by the largest number of species.

Closed-cone pine forest is characterized by the presence of a relatively small number of bird species; about 26 species of birds are in the study area. The principal resources of such areas important to birds are the seeds of the pines and of understory shrubs, and the insects associated with bark and dry litter. Thus, seed-eating birds are the principal users of such areas, but some insectivore species including woodpeckers, flycatchers, nuthatchers, and warblers, may also appear. Predators utilizing the area include hawks and perhaps two species of owls. Certain wide ranging species such as the vulture, red-tailed hawk and swallow can also be expected.

Deciduous forest commonly supports a very diverse community of birds. In the study area some 42 species are associated with this habitat type; this number is low relative to agricultural and grassland habitat types because of the large number of aquatically-oriented species which utilize these last two types. However, the forest type probably does provide cover nest sites, and a place of permanent residence for more species than any other habitat type present in the area of concern. More species of insectivores occur here than in closed-cone pine situations. Species active on or near the ground find food and cover among understory plants and shrubs. In general, the presence of a diverse array of species in the deciduous forest can be attributed to the greater diversity of food types and microhabitat situations present in this community.

Evergreen forest, depending on the actual structure and composition of such communities, may have a quite diverse or relatively depauperate associated bird fauna. In the study area, about 54 species may appear in mature stands of evergreens in which high structural diversity provided by various age classes of trees, and productivity of seeds and insects promote use by a variety of bird species. Areas of secondary growth characterized by even-aged stands of trees are usually relatively sterile in terms of bird fauna. Species characteristic of this forest type include woodpeckers, flycatchers, warblers, and seed-eaters. Blue grouse may occur here. Osprey and band-tailed pigeons nest in areas possessing dead snags of redwood, sitka spruce, or other species. Owl species characteristic of the deep woods are found here. Wide-ranging species such as vultures, red-tailed hawks, swallows, etc. also use this habitat.

Mixed evergreen and deciduous forest is by definition structurally and vegetationally more diverse than the habitat types

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previously discussed and consequently bird species appearing in the component vegetation types can often be found here. In the study area some 57 species of seed-eating, insectivorous, predatory, and other birds may be associated with this vegetation type. Local conditions and seasonal changes can be expected to determine the actual species composition of a given area.

Riparian forest potentially has the highest bird diversity of all woodland or forest habitat types. The availability of water along rivers and streams fosters the development of a structurally complex and taxonomically diverse plant community. Bird species adapted to feeding, resting, or nesting in tree top, shrub stand, and ground cover situations, as modified by their simultaneous occurrence, are attracted to these areas. High plant productivity provides an abundance of seeds, catkins, and fruits for granivorous, frugivorous and omnivorous species. The availability of organic matter (vegetation and debris or detritus) and water provides for high levels of insect productivity which in turn supports higher numbers and diversity of insectivorous than are found in most other areas. About 65 species of migrant and resident birds are expected to utilize riparian habitats in the study area.

Vegetated and sparsely vegetated dune habitats are quite depauperate of regularly occurring bird species. Essentially all species which do appear there feed on insects or small mammals. Falcons, hawks, vultures, burrowing owls and short-eared owls hunt over the dunes usually in areas near those with more vegetation. Ravens and shrikes take insects and occasionally small birds and mammals. Ground-dwelling arthropods are taken by water pipits and flying insects are taken by swallows that may include the dunes in their foraging flights. Accidental occurrences of the snowy owl have been recorded in this habitat type.

Unvegetated dunes (moving sand) do not provide food or cover for bird species to any important extent. Scavenger species, including the vulture and the raven, may forage over such areas in search of carrion or waste material. The red-tailed hawk and the merlin may be seen over dunes as a consequence of their flight patterns. Shorebirds may forage near the juncture of the dune and beach areas. Areas of moving sand constitute barriers to movement between other habitats by many organisms.

Tidal creeks and sloughs are quite productive of fish and invertebrates and are often bordered by salt marshes, which provide cover for bird species. About 49 bird species utilize these estuarine areas at one time or another. The majority of these are waterfowl, shorebirds and wading birds. Swifts and some raptors are known to make foraging flights over such areas. 14 species use tidal sloughs to some extent, the most frequently observed species being willet, marbled godwit, and black turnstone.

Ditches, ponds, and closed channels are important areas for waterfowl in the study locality and are also likely to be utilized by gulls, sandpipers, Osprey, swifts, swallows and martins. The Arcata oxidation pond falls into this category but should be considered a unique site because of its high water temperature and extremely productive algal blooms. A large number of sightings of accidental species, as well as of many regularly occurring species, are made on this site (Yocom and Harris, 1975).

Creeks and rivers are utilized by a large number of waterfowl species; some like the American merganser, prefer rivers to open bodies of water while most are generalists with respect to the water habitat types discussed here. Very few shorebird species are seen. Martins, swifts, and the violet-green swallow are expected to occur, and Osprey hunt in river waters.

Waters of the Humboldt Bay are visited or used regularly by some 70 species of birds; predominate among these are waterfowl, including some diving species that do not occur in shallower waters. Margins of the Bay and mud and sand flats are utilized for feeding and resting by most shorebird species recorded in the study area. Among wading birds, the great blue heron and the cattle egret are reported feeding in Bay waters. All but one species of gull known to occur in the study area are likely to be seen flying and feeding over Bay waters or resting on the surface. Vaux swift, violet-green swallow, and osprey also hunt over this area.

Near-shore ocean waters are a primary use area of loons, grebes, fulmars, pelicans, and cormorants. Geese and a few duck species can also be seen outside the Bay. The ocean margin (i.e., the wave-washed beach) is the principal feeding area for many shorebird species. Snowy plover, sanderling and willet were most commonly observed on the beach and large numbers of least sandpipers were also occasionally seen (Gerstenberg, 1972). A total of 69 species of birds potentially use this habitat in the study area.

Salt marsh habitats are used by a variety of water-oriented birds. Some 34 species have been reported to use such areas in the study locality. Wading birds (with the possible exception of the green heron), waterfowl (teal, shoveler), rails and coots, and about 16 species of shorebirds (including 2 species of plovers) feed on animal (mostly arthropod) and vegetable materials provided by the marsh. Aerial predators include the marsh hawk, short-eared owl, and Vaux's swift. Turkey vulture scavenge in these areas. Accidental sightings of the snowy owl have been made in this habitat type (Yocom and Harris, 1975).

Brackish marsh has not often been distinguished from salt marsh in studies of birds around the Humboldt Bay. Since brackish marsh is vegetationally more diverse and at least as productive as salt marsh (see Habitat Types, Section VI-L), the associated bird

community is also expected to be more diverse. However, only 25 bird species have been included in Table E-5 (Appendix E) under this habitat type on the basis of written reports or extrapolation from them. These are essentially the same species appearing in salt marsh habitat type with the exception of about ten species of shorebirds. Also appearing in brackish areas may be the violet green swallow and the long-billed marsh wren. The lower number of species indicated in this habitat type than for salt marsh may be an artifact of observers classification of the area.

Fresh-water marsh habitats may be utilized by as many as 42 bird species including most of those cited for salt and brackish marsh. The occurrence of plovers, phalaropes, and several shorebird species not reported in brackish areas bring the total number of shorebird species indicated for the area to 18. Fourteen of the 31 species observed by Gerstenberg (1972) utilized fresh-water marsh to some extent; killdeer and Wilson's snipe were the most commonly sighted.

Swamp habitats in the study area are probably grossly underrated as bird use areas by the published literature and the summary provided in Table E-5 (Appendix E). Particular swampy areas containing tall trees are important roosting and nesting areas for the great egret, snowy egret and black-crowned night heron. Many species characteristic of deciduous forest and riparian forest as well as certain marsh-dwelling species such as the long-billed marsh-wren and the yellow throat may be common here, as indicated by the survey of habitat use for Indian (Gunther) Island conducted by Burton (1972). While Burton did not recognize a swamp habitat per se, the results of his survey and the vegetation classification used in this report suggest that his results are applicable to swamp habitat types.

Mudflats in the study area probably provide arthropod and vegetable food materials to over 29 bird species including the water pipit, Vaux's swift, and 25 species of shorebirds. Use of this habitat type was evaluated by Gerstenberg (1972); 29 of the 31 species he observed used the resources of mudflats. Black-bellied plovers, western sandpipers, marbled godwits and willets were commonly observed. Gulls probably appear quite frequently on the mudflat although they have not been reported.

Jetties have not been reported used by bird species in the published and unpublished literature but are probably incorporated in the activities of at least 14 species. The five species of shorebirds that prefer feeding along rocky shores may utilize the margins of jetties. Most species of gulls are likely to use these man-made structures for perching and resting.

Rare and Endangered Species

Five bird species recorded as recent occurrences in the Humboldt Bay area have been described as rare or endangered under the Endangered Species Act of 1973 (PL 93-205). The clapper rail is probably extirpated from its salt marsh habitat around the Bay. The brown pelican is a common summer and fall visitant in bays and lagoons along the coast. The peregrine falcon is thought to breed in the area but no nesting has been reported recently. Bald eagles and the Aleutian Canada geese are migrants through the area (Yocom and Harris, 1975).

O. FISH

Humboldt Bay possesses a diverse fish fauna composed of estuarine and oceanic forms. One-hundred and six (106) species in 43 families have been recorded in the combined collections of numerous separate studies in the Bay and the Mad River estuary. The fish species and sources of collections are shown in Table VI-17. Approximately 50 of the species have been reported in four out of the nine cited collections. The others occur infrequently or are not easily taken by the sampling gear employed. A relatively small number of species can be considered to be abundant. The most abundant species taken in trawl studies and other observations are surfperch, flatfish, herring, anchovies, smelt, and sculpins.

A significant fraction of all species reported from Humboldt Bay and the Mad River estuary utilize these areas as spawning and nursery grounds and/or are year-round or seasonal residents. At least 36 species utilize these areas as a nursery ground and are known to or probably spawn in the Bay and river estuary. Seven of the species are anadromous; that is, they have seasonal migrations from the ocean through the Bay or Mad River estuary to reach freshwater spawning grounds.

The following section discusses the general characteristics of the major fish groups found in Humboldt Bay and the Mad River estuary with descriptions of their body form, size, general habitat preferences and feeding and spawning habits. Only resident or seasonal groups are discussed in detail. For further information on these fish groups the reader should consult DeWitt and Welsh (1977), Hart (1973), or Clemens and Wilby (1961). The taxonomic nomenclature is from Miller and Lea (1972), and DeLacy, Miller and Borton (1972).

The habitats, abundance, location of capture, growth form and resource utilization of all known or suspected resident and seasonal species are given in Table VI-18. The resource value of each group or species is shown as a qualitative assessment. For further information on utilization by commercial and sport fisheries, refer to the Economic Profile.

Lampreys

Lampreys are primitive eel-like fish up to 27 inches (69 cm) long and usually parasitic as adults on various fishes, salmon and trout in particular. All spawning and juvenile phases are in freshwater, but the adults of many species are anadromous. The larvae and juveniles of these species are found in small streams and rivers. The Pacific lamprey, Lampetra tridentata, has been reported in the Mad River (1979).

Table VI-17

CHECKLIST OF FINFISH IN HUMBOLDT BAY

<u>Family</u>	<u>Genus - Species</u>	<u>Common Name</u>
Petromyzonidae	<i>Lampetra tridentata</i> (Gairdner in Richardson)	Pacific Lamprey
Hexanchidae	<i>Notorynchus maculatus</i> Ayres	Sevengill shark
Carcharhinidae	<i>Mustelus henlei</i> (Gill)	Brown mouthhound
	<i>Triakis semifasciata</i> Girard	Leopard shark
	<i>Galeorhinus zyopterus</i> (Jordan and Gilbert)	Soupfin shark
Rajidae	<i>Raja binoculata</i> Girard	Big skate
Dasyatidae	<i>Urolophus halleri</i> Cooper	Round stingray
Myliobatidae	<i>Myliobatis californica</i> Gill	Bat ray
Chimaeridae	<i>Hydrolagus colliei</i> (Lay and Bennett)	Ratfish
Acipenseridae	<i>Acipenser medirostris</i> Ayres	Green sturgeon
Ophichthidae	<i>Ophichthus zophochir</i> Richardson	Yellow snake eel
Clupeidae	<i>Alosa sapidissima</i> (Wilson)	American shad
	<i>Clupea harengus pallasii</i> Valenciennes	Pacific herring
	<i>Dorosoma petenense</i> (Gunther)	Threadfin shad
Engraulidae	<i>Engraulis mordax</i> Girard	Northern anchovy
Salmonidae	<i>Oncorhynchus kisutch</i> (Walbaum)	Coho salmon
	<i>Oncorhynchus tshawytscha</i> (Walbaum)	Chinook salmon
	<i>Oncorhynchus gorbusha</i> (Walbaum)	Pink salmon
	<i>Salmo gairdneri</i> Richardson	Steelhead rainbow trout
	<i>Salmo clarkii</i> Richardson	Coastal cutthroat trout
Osmeridae	<i>Allomerus elongatus</i> (Ayres)	Whitebait smelt
	<i>Hypomesus pretiosus</i> (Girard)	Surf smelt
	<i>Spirinchus starski</i> (Fisk)	Night smelt
	<i>Spirinchus thaleichthys</i> (Ayres)	Longfin smelt
	<i>Thaleichthys pacificus</i> (Richardson)	Eulachon
Gonostomatidae	<i>Cyclothone acclinidens</i> (Günther)	Benttooth bristlemouth
Myctophidae	<i>Stenobrachius leucopsarus</i> (Eigenmann and Eigenmann)	Northern lampfish
	<i>Tarletonbeania crenularis</i> (Jordan and Gilbert)	Blue lanternfish
Gadidae	<i>Microgadus proximus</i> (Girard)	Pacific tomcod
Ophidiidae	<i>Otophidium taylori</i> (Girard)	Spotted cusk-eel
Atherinidae	<i>Atherinops affinis</i> (Ayers)	Topsmelt
	<i>Atherinopsis californiensis</i> Girard	Jacksmelt
Trachipteridae	<i>Trachipterus altivelis</i> Kner	King-of-the-salmon
Gasterosteidae	<i>Aulorhynchus flavidus</i> Gill	Tube-snout
	<i>Gasterosteus aculeatus</i> Linnaeus	Threepine stickleback
Syngnathidae	<i>Syngnathus griseolineatus</i> Ayres	Bay pipefish
Serranidae	<i>Cynoscion nobilis</i> (Ayres)	White seabass
	<i>Stereolepis gigas</i> (Ayres)	Giant seabass
	<i>Roccus (Morone) saxatilis</i> (Walbaum)	Striped bass
Sciaenidae	<i>Cynoscion nobilis</i> (Ayres)	White seabass
	<i>Genyonemus lineatus</i> (Ayres)	White croaker
Embiotocidae	<i>Amphistichus koelzi</i> (Hubbs)	Calico surfperch
	<i>Amphistichus rhodotermus</i> (Agassiz)	Redtail surfperch
	<i>Cymatogaster aggregata</i> Gibbons	Shiner perch

Table VI-17 (continued)

<u>Family</u>	<u>Genus - Species</u>	<u>Common Name</u>
	<i>Embiotoca lateralis</i> Aggasiz	Striped seaperch
	<i>Hyperprosopon argenteum</i> Gibbons	Walleye surfperch
	<i>Hyperprosopon ellipticum</i> (Gibbons)	Silver surfperch
	<i>Phanerodon furcatus</i> Girard	White seaperch
	<i>Rhacochilus vacca</i> (Girard)	Pile perch
Trichodontidae	<i>Trichodon trichodon</i> (Tilesius)	Pacific sandfish
Stichaeidae	<i>Anoplarchus purpurascens</i> Gill	High cockscomb
	<i>Cebidichthys violaceus</i> (Girard)	Monkeyface prickleback
	<i>Lumpenus sagitta</i> Wilimovsky	Snake prickleback
Pholidae	<i>Apodichthys flavidus</i> Girard	Penpoint gunnel
	<i>Pholis ornata</i> (Girard)	Saddleback gunnel
Anarrhichadidae	<i>Anarrhichthys ocellatus</i> Ayres	Wolf-eel
Cryptacanthodidae	<i>Delolepis gigantea</i> Kittlitz	Giant wrymouth
Ammodytidae	<i>Ammodytes hexapterus</i> Pallas	Pacific sand lance
Gobiidae	<i>Clevelandia ios</i> (Jordan and Gilbert)	Arrow goby
	<i>Eucyclogobius newberryi</i> (Girard)	Tidewater goby
	<i>Lepidogobius lepidus</i> (Girard)	Bay goby
Luvaridae	<i>Luvarus imperialis</i> Rafinesque	Louvar
Stromateidae	<i>Peprilus simillimus</i> (Ayres)	Pacific butterflyfish
Scorpaenidae	<i>Sebastes auriculatus</i> Girard	Brown rockfish
	<i>Sebastes caurinus</i> Richardson	Copper rockfish
	<i>Sebastes elongatus</i> Ayres	Greenstriped rockfish
	<i>Sebastes melanops</i> Girard	Black rockfish
	<i>Sebastes mystinus</i> (Jordan and Gilbert)	Blue rockfish
	<i>Sebastes paucispinis</i> Ayres	Bocaccio
	<i>Sebastes rastrelliger</i> (Jordan and Gilbert)	Grass fockfish
Hexagrammidae	<i>Hexagrammos decagrammus</i> (Pallas)	Kelp greenling
	<i>Hexagrammos lagocephalus</i> (Pallas)	Rock greenling
	<i>Ophiodon elongatus</i> Girard	Lingcod
	<i>Oxylebius pictus</i> Gill	Painted greenling
Cottidae	<i>Artedius fenestralis</i> Jordan and Gilbert	Padded sculpin
	<i>Artedius harringtoni</i> (Starks)	Scalyhead sculpin
	<i>Artedius notospilotus</i> Girard	Bonyhead sculpin
	<i>Ascelichthys rhodurus</i> Jordan and Gilbert	Rosylip sculpin
	<i>Blepsias cirrhosus</i> (Pallas)	Silverspotted sculpin
	<i>Clinocottus acuticeps</i> (Gilbert)	Sharpnose sculpin
	<i>Cottus asper</i> Richardson	Prickly sculpin
	<i>Enophrys bison</i> (Girard)	Buffalo sculpin
	<i>Hemilepidotus hemilepidotus</i> (Tilesius)	Red Irish lord
	<i>Hemilepidotus spinosus</i> (Ayres)	Brown Irish lord
	<i>Leptocottus armatus</i> Girard	Pacific staghorn sculpin
	<i>Nautichthys oculoasciatus</i> (Girard)	Sailfin sculpin
	<i>Oligocottus snyderi</i> Greeley	Fluffy sculpin
	<i>Scorpaenichthys marmoratus</i> (Ayres)	Cabezon

Table VI-17 (continued)

<u>Family</u>	<u>Genus - Species</u>	<u>Common Name</u>
Agonidae	<i>Odontopyxis trispinosa</i> Lockington	Pygmy poacher
	<i>Pallusina barbata</i> (Steindachner)	Tubenose poacher
	<i>Stellerina myosterna</i> (Jordan and Gilbert)	Pricklebreast poacher
Cyclopteridae	<i>Liparis fucensis</i> Gilbert	Slipskin snailfish
	<i>Liparis pulchellus</i> Ayres	Showy snailfish
	<i>Liparis rutteri</i> (Gilbert and Snyder)	Ringtail snailfish
Bothidae	<i>Citharichthys stigmaeus</i> (Jordan and Gilbert)	Speckled sanddab
Pleuronectidae	<i>Paralichthys californicus</i> (Ayres)	California halibut
	<i>Isopsetta isolepis</i> (Lockington)	Butter sole
	<i>Lepidopsetta bilineata</i> (Ayres)	Rock sole
	<i>Microstomus pacificus</i> (Lockington)	Dover sole
	<i>Parophrys vetulus</i> Girard	English sole
	<i>Platichthys stellatus</i> (Pallas)	Starry flounder
	<i>Pleuronichthys decurrens</i> Jordan and Gilbert	Curlfin sole
Cynoglossidae	<i>Psettichthys melanostictus</i> Girard	Sand sole
	<i>Symphurus atricauda</i> (Jordan and Gilbert)	California tonguefish
Molidae	<i>Mola mola</i> (Linnaeus)	Ocean sunfish

Sharks, Skates, and Rays

These are medium to large marine benthic to pelagic fish, all bearing their young alive or encapsulated in horny egg cases. Sharks are high level carnivores but most species tend to be omnivorous. The smaller inshore species frequently feed upon crustaceans and molluscs. Food of the rays and skates consists mostly of bivalves, but polychaete worms, shrimp, echuroids, crabs, and tunicates also make up a significant fraction of their diet.

Sturgeon

Only the green sturgeon, Acipenser medirostris, has been reported in the study area. This is a long-lived fish that can reach lengths of up to seven feet (213 cm). The green sturgeon is a demersal species preferring saline waters. During high freshwater inflow, they may move out of the study area (Skinner, 1962). Young green sturgeon feed on insect larvae and mysid shrimp, while adults eat eulachon, sculpins, stickleback, lamprey, ghost shrimp, and young sturgeon (Dees, 1961).

Herring, Shad, and Anchovy

These are soft-rayed fishes related to the salmon and trout. All are small to medium sized fish reaching lengths of seven to 30 inches (18 to 76 cm). This group is pelagic to demersal and often occur in schools in inshore and offshore waters.

The spawning habits of each species varies considerably. Herring spawn demersal eggs which adhere to eelgrass, kelp, and sometimes rocks and trash. Anchovy spawn pelagic eggs at sea in the summer and mature adults are absent from bay and estuaries during that time (Hart, 1973; Waldvogel, 1977). Shad spawn in the late spring, usually in the lower reaches of rivers and streams. After hatching the larvae drift downstream and reach the estuaries at least by early fall (Hart, 1973).

Rabin (1976) estimated spawning stock sizes for Humboldt herring at 372 tons (338,248 kg) and 241 tons (219,208 kg) for the winters 1974-75 and 1975-76, respectively. All of the spawning took place on eelgrass beds in Arcata Bay and south Humboldt Bay over an area of 829 hectares. The heaviest spawning was concentrated in the southern portion of Arcata Bay (shown in Plate 8a). He obtained estimates of 7,500 and 6,800 eggs per meter square (697 and 632 per square foot) in the 1974-75 and 1975-76 spawning periods, respectively. Spawning began in the middle of December and ended in early March, with approximately 99% of all spawning occurring between December 14 and February 14.

Misitano and Peters (1969) found that anchovy in Humboldt largely feed on benthic copepods, and other benthic crustaceans and diatoms (69% of the total diet). Herring were found to be feeding predominantly on pelagic copepods (69% of the total diet). Shad at sea feed primarily on planktonic crustaceans (Hart, 1973).

Herring and anchovy are important commercial species and major food source for many organisms including coho and chinook salmon, lingcod, marine mammals, larger invertebrates and waterbirds. In addition, the eggs are eaten by fishes and waterfowl, and the larvae are consumed by plankton feeding fishes and invertebrates.

Salmon and Trout

A number of species of these commercially valuable fish occur in coastal northern California waters and a detailed examination of the major aspects of their life histories has been presented in DeWitt and Welsh (1977). All of the anadromous species make extensive use of estuarine waters as juveniles or smolt. Coho (Oncorhynchus kisutch), and chinook (O. tshawytscha) salmon and the steelhead trout (Salmo gairdneri), are the most common species in the study area. The coastal cutthroat trout (Salmo clarkii) also has been reported as an infrequent migrant. The coho salmon (also called silver salmon) can reach a length of 38 inches (97 cm) and a weight of 33 pounds, with an average size at maturity of 10 pounds. Adult coho at sea feed on squid, pelagic shrimp, and fish. Out-migrating young feed mainly on insects in fresh and brackish waters. In the estuaries they begin to feed on crustaceans and small fish such as herring, sand lance, greenling, rockfish, and eulachon.

Chinook salmon (also called king or spring salmon) is the largest salmon species in the study area. They reach sizes of 58 inches (147 cm) and 126 pounds, but are usually much smaller, with an average size at maturity of 15 pounds. Adults while at sea feed mainly on smaller fish. Food of young chinook salmon is similar to the coho salmon.

Steelhead trout reach sizes of 40 inches (102 cm) and 36 pounds but the average size at maturity is 6-8 pounds. The adults at sea feed on crustaceans, squid, herring, and other fishes (Clemens and Wilby, 1961). Humboldt Bay is utilized as a nursery and feeding area for young salmonids and as a feeding and rest area for adult fish. However, most fish contributing to the offshore population in the Eureka area originate from the Eel and Mad Rivers and other larger coastal streams. Monroe (1973) stated that stream habitat within the Bay has been adversely affected by siltation, alteration of natural stream courses, water diversions, and pollution. As a result, spawning migrations into most Bay streams have been greatly reduced or eliminated.

The following is a list of streams entering Humboldt Bay, with Monroe's evaluation of the present status of the anadromous fisheries in each:

Mad River Slough: At the present time Mad River Slough does not produce any anadromous fish although it may provide some nursery area for juvenile salmonids.

Eureka Slough: Eureka Slough serves primarily as a passageway for salmonids migrating into and out of upstream areas. It may provide some nursery area for young salmonids, however, the extent of this use is unknown. Pollution of the waters of Eureka Slough has raised questions concerning the survival of fish.

Ryan Slough: Ryan Slough has populations of silver salmon and cutthroat trout. The stream has been damaged by siltation.

Freshwater Slough: Freshwater Creek is an important spawning tributary for steelhead and salmon. It has been planted in the past by the Department of Fish and Game and is currently being planted with king salmon by the Fish Action Council, a local group which was formed to restore salmon runs in Humboldt Bay. Fish entering Freshwater Creek must pass through the slough which has been channelized, has silted in, and may have low oxygen problems.

Liscom Slough: Liscom Slough has no known value to anadromous fishes. The habitat is not suitable for spawning.

McDaniel Slough and Jones Creek: This drainage presently does not support any anadromous fish. It is heavily silted and is subjected to industrial and domestic pollution.

Beith Creek: Silver salmon were known to spawn in this creek until a diversion dam was constructed to provide water for a duck club. Anadromous fish can no longer ascend the stream. Resident cutthroat are present.

Jacoby Creek: Jacoby Creek is an important salmon and steelhead stream in addition to providing a summer trout fishery. Both rainbow and cutthroat trout are present. In the past the stream has been stocked with steelhead and cutthroat trout.

Washington and Rocky Gulches: Washington Gulch supports a population of cutthroat trout. Rocky Gulch once had populations of silver salmon and trout. Heavy siltation from logging operations has eliminated these populations in the lower part of the gulch although salmonids may still be present in the headwater portions of the stream.

Fay Slough: The upper portions of Cochran and Redmond Creeks have populations of trout. The lower portions of the streams are heavily silted in with little or no fish habitat.

Cooper Canyon: Cooper Canyon and the two unnamed streams entering Eureka Slough just east of Cooper Canyon do not now support anadromous fish populations.

Elk River: Elk River is the major salmon and steelhead spawning tributary of Humboldt Bay. It is used by both salmon and steelhead. The Elk River system is currently being planted with 40,000 yearling silver salmon each year. Log jams have been removed in recent years to allow full utilization by anadromous fish.

Salmon Creek: This drainage may support a few steelhead but the current status of salmon populations is not known. The stream remains muddy through the winter while other streams in the area clear up. A tidegate at the mouth impedes the movement of fish into the stream.

Monroe (1973) anticipated further deterioration of the remaining spawning and rearing habitat in Humboldt streams as a consequence of continued disturbances. He noted that while plantings from the Mad River hatchery will augment natural production, they are not likely to restore the runs to pre-development levels without significant improvements in stream habitat.

Smelt and Silversides

The smelt and silversides are herring-like fish common throughout the inshore areas and bays of California. Smelt are essentially marine, although some species are anadromous or spend all of their lives in fresh water. Maximum length in most smelt species is about 10 inches (25 cm). Spawning takes place on sandy beaches

in salt or fresh water with spawning peaks from May through October. Smelt in marine waters feed on small crustaceans, but will eat a variety of polychaete worms, larval fish, jellyfish, and other suitable food organisms. They are used commercially and are forage fish for salmon and other large predatory species.

The silversides include such well-known species as the California grunion, top smelt and jack smelt. Silversides are generally found in loose schools at or near the surface with the largest individuals about 14-1/2 inches (36.8 cm) in length. They spawn in marine and estuarine waters in the late winter and spring and attach their eggs to eelgrass, algae, and other similar substrate just below low water. Silversides feed within a foot of the surface over shallow rocky areas or eelgrass beds. Their food is a variety of small invertebrates including planktonic crustaceans and insect larvae. They can be an important forage fish and are fed upon by seabirds and predatory fishes.

Cod

The cod are represented in the Pacific by whiting, tomcod, Pacific cod, and longfin cod, as well as the related cod-like Pacific hake. Only the Pacific tomcod, Microgadus proximus, has been collected in the Humboldt study area.

Other cod-related species such as the hake have been reported near-shore outside the Humboldt Bay area (DeWitt, 1952).

The Pacific tomcod is a common fish of the northern California coast and in appearance closely resembles the other cod species. It reaches a maximum length of about 12 inches (31 cm) and feeds mainly on shrimp (Hart, 1973). Young tomcod feed on small benthic invertebrates.

Rockfish

The rockfish or rock cod family is the most diverse group of marine fishes found in California, with four genera and 62 described (Phillips, 1957) species. They are common in waters less than 150 feet (46 meters) in depth, and tend to occupy rocky habitats and piers as adults and mudflats, sand bottoms, and channels as juveniles. Rockfish will reach lengths of three feet (91 cm), but are usually no longer than 20 inches (51 cm). Many rockfish species are highly territorial and exhibit little intermingling between stocks, except during the larval period. All species have internal fertilization, and the embryos develop within the ovaries. The females liberate the very immature larvae in the winter. The food of the adult rockfish generally consists of squid, octopi, crabs, shrimp, and small fish. Small or medium-sized individuals may be eaten by lingcod and other large predatory fish, and marine mammals such as harbor seals. Prince (1972) found rockfish on an artificial

reef in South Bay to be utilizing food organisms associated with the reef and other organisms that were living in the immediate reef area. These rockfish fed primarily on arthropods. Three of the most important individual food items were Dungeness crab (Cancer magister), gammarid amphipods, and bay shrimp (Crago sp.) Fishes were also an important food group and eelgrass was consumed incidentally with other food organisms. Younger fish were observed to contain large numbers of the parasitic pea crab, Pinnixa faba, which lives in the siphon of clams; in particular, the horseneck or gaper clam, Tresus capax. Rockfish are of major importance in the commercial and sport fisheries.

Stickleback, Tubesnout, and Pipefish

These are a group of closely related small fish inhabiting marine, estuarine, and fresh waters. Both the tubesnout and stickleback are nest builders, and all fish in this group utilize estuaries as spawning and nursery areas. These fish feed upon insect larvae, benthic crustaceans, and young of fish such as herring and rockfish. They are, in turn, a food source for waterbirds and many species of larger fish.

Surfperch

Surfperch, or sea perch, are a cosmopolitan group of perch-like fish distributed along the shores of the Pacific coast. All members of this group are viviparous and marine, except for one which lives in streams in central California.

Surfperch reach a maximum length of 12 to 15 inches (35 to 38 cm) and have been reported to depths of 480 feet (146 meters). They mate during the entire year, but young are usually born during the spring and summer months. They will produce from 4 to 100 young, depending on species and size. Eight species of perch have been reported from the study area. The shiner perch, Cymatogaster aggregata, was both the smallest and the most numerous of the perches found in Humboldt Bay (Samuelson, 1973; Sopher, 1974). Young shiner perch are known to eat copepods and various forms of algae. Adults have been seen feeding on barnacles and mussels and other benthic invertebrates. Other perch are omnivores, and the principal food items are crustaceans and algae. They are taken in sport and commercial fisheries and are important forage fish for birds, larger fish species, and marine mammals.

Greenling and Lingcod

These fish are inhabitants of rock, and algae and seagrass covered habitats, and are closely related to the rockfish and sculpin groups. They have been reported from the intertidal zone to depths of 250 feet (76 meters) and reach lengths of nearly 40 inches (101 cm) in California. They usually spawn in the winter to early spring, with some species spawning throughout the year. The eggs are deposi-

ted in masses on low-growing algae and protected rocky areas in the subtidal area. After fertilizing the eggs, the males of many species guard the eggs until they are hatched. The food of the greenling consists of a variety of crustaceans, polychaete worms, small fish, and other lingcod. Prince (1972) found them to be feeding primarily on small crustaceans, polychaete worms, butter clams, and miscellaneous material. The lingcod feeds chiefly on other fish including herring, flounders, and rockfish, and may feed incidentally on squid and various crustaceans.

Humboldt Bay and, in particular, the areas around the entrance, seawalls, and jettys, provides spawning and nursery areas for both the greenling and lingcod. These areas would not only be important for resident fish, but may also provide recruitment stock for fish located as adults along the adjacent open coastline.

Sculpins

Sculpins, which are related to the rockfish, are generally a small to medium size fish with lengths from a few inches to 39 inches (99 cm). They inhabit tide pools, shallow shorewaters, and subtidal waters to depths of 600 feet or more (greater than 180 meters). They are frequently found in rocky intertidal to subtidal zones almost exclusively, but some species occur in muddy or sandy shallow bottomed bays and estuaries. A few species live in fresh water where they are usually known as bullheads. A total of 15 species have been reported in the project area, more than for any other fish group. One species, the staghorn sculpin, was one of the most abundant and widely distributed fish in Humboldt Bay.

Sculpins usually spawn from early winter through mid-spring, and the eggs are laid as masses which are attached to the substrate. Sculpins are known to be a food source for waterbirds, and feed mainly on various types of invertebrates such as crustaceans, polychaete worms, marine snails, and larval to adult fish. Porter (1964(2)) stated that the predominant foods of the staghorn sculpin (Leptocottus armatus) in euryhaline environments, including Humboldt Bay, were amphipods, bay shrimp (Crago sp.) and crabs (Cancer magister).

Poachers and Snailfish

These fish are allied with the sculpins and rockfish but are distinctly different in appearance. The poachers are small fish, no more than eight inches (20 cm) in total length and are distinguished by a non-overlapping armor of bony plates which completely cover the body. They are distributed from the intertidal zone to depths of at least 2,000 feet (610 m) on rocky or muddy bottoms. Poachers feed on tiny crustaceans picked up on the bottom or very close to it. They have no specific predators but are probably eaten by most predatory fish. No life history information appears to exist for these fish.

The snailfish have an elongate body covered by a thin, loose skin. Scales are entirely absent. They usually live on rocky to firm mud-bottom areas from the intertidal zone and tidepools to depths of 12,000 feet (3,600 m) or more. The pelvic fins are often adapted to form an adhesive disk, much like in the gobies. The maximum reported length of all species is 12 inches (35 cm). They probably spawn in the winter and spring. Snailfish are omnivores and would be eaten by other mud-sand bottom habitat fish.

Seabasses and Croakers

A variable group of perch and bass-like species, some may reach lengths of seven feet (2.1 m) and weights of over 550 pounds (250 kg). They may be solitary or form loose schools and are usually found over rocky bottoms or areas with good kelp cover. Frequently, they hide in caves and crevices during the day and forage over sandy or muddy bottoms at night. Spawning time varies between species and all release pelagic eggs. Croakers feed on small crustaceans, polychaete worms, and molluscs, while the seabass usually prey on other fish. They are frequently taken by sport fisheries.

Blenny and Goby-like Fishes

These fish include the gobies, wolf-eels, pricklebacks, gunnels, and sandlances. With exception of the wolf-eel, they are all small and often cryptic fish less than 10 inches (25 cm) in length.

Gobies

Gobies are a diverse and large group, but relatively few species occur in coastal waters of northern California. The pelvic fins in the gobies are usually fused to form an adhesive disc. Most live in tidepools and shallow, rocky intertidal zones on open coasts and estuaries. Gobies spawn demersal, non-adhesive eggs from December through August (Hart, 1973). They feed on small gastropod molluscs and crustaceans and can be an important forage food. The adults are often taken by bass, greenling, and rockfish.

Wolf-eel

The wolf-eel is similar in appearance to the moray eel and reaches lengths of up to six feet (203 cm). It inhabits shallow rocky areas to depths of 400 feet (122 m). The wolf-eel spawns in the winter, attaching an egg mass to protected surfaces of caves or crevices. They are predominantly crab eaters, but will also eat sea urchins, snails, fish, and smaller wolf-eels. Small individuals have been found in the stomachs of salmon.

Pricklebacks

Pricklebacks are similar in appearance and behavior to the blennies and gobies. They are up to 20 inches (51 cm) long and have been reported from shallow bays to depths in excess of 900 feet (274 m). The adults feed on assorted small invertebrates along with much sediment and plant material (COE, 1976(1)). The young feed mainly on copepods (Hart, 1973).

Gunnels

The gunnels are also blenny-like and are restricted to intertidal and shallow subtidal zones, usually being reported no deeper than 240 feet (73 m). They are found on muddy/sandy bottoms within patches or beds of eelgrass, surf grass, or seaweeds. The gunnels are brightly colored fish reaching a maximum length of 18 inches (46 cm). They spawn in the late winter and spring and both sexes guard the eggs. Their diet consists of small crustaceans and shelled molluscs.

Sandlances

The sandlances are elongate fish occurring in schools in the intertidal zone and near-shore to depths of 60 feet (18 m). They are usually found only over sandy bottoms and sometimes can be seen buried in the sand. The adults are at most eight inches (20 cm) in length. Sandlances spawn in shallow water during spring months and the larvae are abundant in the summer. They feed on small crustaceans and are fed upon by salmon, lingcod, crabs, and other larger predators.

Flatfish

Flatfish are all greatly compressed, with the eyes in adults and juveniles on one side of the head. Three of the five families are represented in Humboldt. There are two common families: the sanddabs, in which the eyes are on the left side of the fish, and the flounders, or sole, in which the eyes are on the right side. Flatfish occur from 10 feet (3 m) to abyssal depths, but most live in water of moderate depths. Usually they are found over sand/mud to gravel bottoms and some occur in rocky areas. The adults range in length from six inches (15 cm) for the speckled sanddab, to eight feet (2.4 m) for the Pacific halibut.

The most abundant species in the study area is the English sole, Parophrys vetulus, a commercially important flatfish which attains a maximum length of 22 inches (56 cm). This species spawns offshore from approximately January through March with peak spawning in late February. The floating eggs are then transported toward shore when the larvae develop, and are apparently swept into coastal estuaries by tidal currents. The larvae develop further in the estuaries, and upon metamorphosis settle and/or migrate to shallow,

sandy-bottomed areas within the estuary. English sole juveniles are found only in such areas. Bays and estuaries are, therefore, vital as nursery areas for P. vetulus in their first year of life. Misitano (1970) has traced the movement and growth of the English sole in the Bay. Entry peaks in the spring but limited recruitment occurs year around. By late September, Misitano observed declining catch rates associated with an apparent outmigration of juveniles. Only a small percentage of the juveniles remain in the Bay through the winter. Misitano's mark-recapture method estimate of the number of juveniles in Humboldt in 1969 was 139,899. He stated, however, that his methods probably underestimated actual abundance.

The starry flounder, Platichthys stellatus, is another common flounder species found in the study area. These fish reach a length of up to 36 inches (91 cm) and inhabit coastal waters, bays, inlets, and river mouths along the coast. They are noted for their wide tolerance to differing salinities and bottom types, although they seem to prefer soft sand.

Sanddabs are also frequently taken in Humboldt Bay, but other flatfish species are rarely encountered. The dover or slime sole (Microstomus pacificus) is one of the most abundant offshore species (Hagerman, 1952); however, it is not taken in the Bay

Young flatfish feed on plankton, but as they grow, their feeding shifts to crabs, shrimp, marine worms, clams, and clam siphons (Clemens and Wilby, 1961). The diet of starry flounder in Humboldt Bay consists of eastern softshell clams, Mya arenaria, amphipods, polychaete worms, and the larvae of the crane fly, Hexatoma sp. (Porter, 1964(1)).

Summary

The regional characteristics of the distribution and abundance of fish in Humboldt Bay is a function of the species niche, where the niche is the total role of a species in the community. Since each population of a given species is adapted to a distinct niche, many species can normally coexist in essentially similar areas.

In Humboldt, fish species diversity and abundance are controlled primarily by the following:

- . Habitat (in this sense, the substrate and associated food sources)
- . Water Characteristics (physical factors)
- . Water Quality (chemical and biological factors)

These factors include the total set of environmental elements that determine the preference of the species in question. Key elements in the Humboldt system are substrate availability and type, tidal flushing, salinity, temperature, and nutrients.

Habitat availability to fish in the bay varies with the tidal cycle in that a large portion of Arcata Bay and South Bay are exposed at low water. The eelgrass beds and mudflats do not go entirely dry, however, and much water is retained in shallow depressions and as interstitial water. In addition to the exposure on mudflats and shallows, the floors of major channels are regularly disturbed by dredging to maintain their depth for shipping. Also, much habitat in wetlands that once would have been available to fish has been removed by levee construction (Section VII.A, Land Use).

A large fraction of the area in the bay is noted as mud and sandflat (see Section VI.L, Habitat Types) and there is very little rocky-rubble in addition to artificial structures such as piers and bulkheads. Most fish known from Humboldt Bay are adapted to these shallow mud and eelgrass-covered flats. Pelagic species are rare and rocky-substrate dependent types such as rockfish occur infrequently or are limited to reefs and jetties near the entrance to the bay. This is reflected in the habitat listing shown in Table VI-18. Other habitat types important in terms of fish production are the shallow tidal channels and sloughs and the edges of the deeper channels (Table VI-18).

Tidal flushing and currents are undoubtedly major factors influencing, in particular, the reproductive success of species having pelagic eggs and larvae (i.e., anchovy). Hydraulic model experiments (Section VI.I., Hydraulics) demonstrate that flushing rates vary considerably. Locations in the Bay with low flushing rates (for example, the northeast portion of Arcata Bay), may favor the recruitment of these species. Likewise, tidal currents are probably necessary to sustain the recruitment of offshore spawners, such as English sole, into the Bay.

Characteristics of the water column in Humboldt Bay have been shown to exhibit marked seasonal variation only in the shallow flats and sloughs (Section VI.K, Water Quality). Freshwater input, which is dominated by storm pulses and salinity, especially in Arcata Bay, varies unpredictably. Only species adapted to euryhaline environments such as sculpins and surfperch could utilize these waters during freshwater pulses. Otherwise, the Bay has very little freshwater influence and fish speciation is normally more typical of oceanic conditions. Marked temperature fluctuations have been reported over shallow waters (Section VI.I, Hydraulics) but are probably insignificant in their effect on fish distribution. Nor is there any evidence that fish distribution is limited by dissolved oxygen. Fish do tend to concentrate, however, at the thermally enriched Pacific Gas and Electric power plant cooling water discharge.

Fish production in Humboldt Bay is linked to nutrient inputs from offshore upwelling, runoff and in-bay nitrogen fixation as reflected in phytoplankton and zooplankton production. Reproduction and

larval rearing are timed to coincide with peaks in plankton production and natural or man-induced changes in production can alter spawning success and survival. Spawning seasonality for Humboldt area fish is illustrated in Table VI-18.

The adaptations of a given species to environmental factors in Humboldt Bay varies between species and with the growth stage and size of the fish. The critical habitat requirements of fish in the Bay do not always have clear spatial limits and distribution and abundance may be influenced by factors such as offshore recruitment success, upwelling, storms, and inter-species competition. Most larvae and many juveniles in the Bay occupy overlapping habitats and the populations are probably strongly competitive, although each species may develop specialized feeding habits early in its growth. Species diversity is optimized in areas exhibiting moderate fluctuations in temperature, salinity, water exchange, and good water quality. The identification of eelgrass beds and inner channel areas as prime larval and juvenile rearing areas in the Bay is, therefore, contingent upon maintenance of water quality, productivity, and hydraulic values in the surrounding waters.

As adults, primarily benthic species frequently have narrow habitat requirements with regard to substrate preference. There are many resident fish (see Table VI-18) within the Bay for which habitat character based solely on substrate may adequately define their distribution. Examples are most flatfish, rockfish, greenling, and the goby-like fish. On the other hand, the distribution of some species may be ill-defined by substrate type. Examples are the sculpins and sticklebacks which are tolerant of wide temperature and/or salinity fluctuations, or the surfperch and sharks which bear their young alive so that reproduction is not dependent on larval survival. Other species, such as herring and salmon, are seasonal and adapted to short-term utilization of the Bay when primary production is at a peak (Table VI-18).

The fish of Humboldt Bay have significant economic value and augment production of offshore stocks of commercial species such as English sole and anchovy. These waters also support undetermined numbers of fish such as herring, surfperch, and sanddabs which are taken by the commercial and sport fisheries within the Bay (Table VI-18). For a discussion of the economic impact of the Bay fisheries, see Section VIII.C., Economic Profile.

Key List for Table VI-18

SUMMARY OF BIOLOGICAL INFORMATION ON FISH GROUPS

ABUNDANCE:	4	Abundant - always taken, in the top 10 of species reported by Sopher (1974) and Samuelson (1973)
	3	Common - usually taken or seen
	2	Occasional - sometime taken or seen
	1	Uncommon - rarely taken or seen
HABITAT:		DTS - deep tidal channels
		STS - shallow tidal channels
		TCSSW - tidal creeks and sloughs, predominantly saltwater
		TCSFW - tidal creeks and sloughs, predominantly freshwater
		MF - mudflats
		CR - creeks and rivers
RESOURCE VALUE:	4	Commercial species
	3	Sport species
	2	Forage species as adult (all species eaten as eggs-juveniles)
	1	Pest or nuisance species
	0	Value undetermined or minor (i.e., limited aquarium trade)
REFERENCE:	0	Army Corps of Engineers, 1976
	1	Barnhart, 1979
	2	Boomer, 1970
	3	DeGeorges, 1972
	4	DeLarm, 1977
	5	DeWees and Gotshall, 1974
	6	Eldridge, 1970
	7	Gingerich, 1971
	8	Hart, 1973
	9	Misitano, 1970
	10	Monroe, 1973
	11	Pollard, 1977
	12	Prince, 1972
	13	Rabin, 1976
	14	Samuelson, 1973
	15	Smith, 1967
	16	Sopher, 1974
	17	Stein, 1972a
	18	Stein, 1972b
	19	Taniguchi, 1970
	20	Waldvogel, 1977
	21	Will, 1979

Table VI-18
SUMMARY OF BIOLOGICAL INFORMATION ON FISH GROUPS

Group	Common Name	Abundance	Life History Type				Seasonality	Location	Preferred Habitat Type	Utilization of Site				Comments	Reference
			Eggs	Larvae	Juveniles	Adults				Resident	Anadromous	Spawning	Nursery		
Lampreys	Pacific Lamprey	3	?		?	X	seasonal	Mad River.	TCSFW, CR		X	X	X	1 Important predator on salmon and trout; can be used commercially. Adults in freshwater only during spawning.	21
Sharks, Shales, and Rays	Brown Smooth Hound	3			X	X	year-round	Shallow mudflats and channels, Humboldt Bay.	STS, MF	X			X	3	2
	Leopard Shark	2			X	X	year-round	Shallow mudflats and channels, Humboldt Bay.	STS, MF	X			X	3	2
	Big Skate and Bat Ray	2	X		X	X	year-round	Shallow sand and mudflats and shallow channels.	STS, MF, TCSSW	?			?	1,4 Thought to be a pest on oyster & clam beds; can be sold but are of low value.	2
	Other Sharks	1			?	X	year-round	Deep channels and mouth of bay.	DTS, MF					0,1 Larger sharks may be dangerous; some species valuable commercially but too rare in Humboldt Bay.	2
Sting Rays	Sting Rays	1			?	X	year-round	Mudflats.	DTS, MF					0,1 Larger sting rays may be dangerous; some species valuable commercially but too rare in Humboldt Bay.	2
	Green Sturgeon	1			?	X	year-round	NE portion of Arcata channel; scattered elsewhere. Mad River?	STS, MF, TCSSW	?			?	0	16
Herring, Shad, and Anchovy	American Shad	2			X	X	year-round; most common in spring or early summer	NE portion of Arcata channel, Arcata small boat basin, South Bay, Mad River to Blue Lake Bridge.	STS, MF, CR		X	X	X	An introduced species. Adults in fresh water only during spawning.	3, 14, 15, 21
	Pacific Herring	4	X	X	X	X	seasonal; adults most common Oct. to June; adults and juveniles most common April-May, occur from Jan.-June	Spawning adults on eelgrass beds and shallow channels in Arcata Bay and South Bay - 99% of egg deposition in Arcata Bay, 80% of which is on beds SE of Bracut Channel. Larval forms distributed throughout Bay and are also found in the sloughs.	MF, STS			X	X	4,2 6th and 8th most abundant species in trawl samples from South Bay and Arcata Bay respectively. Adults most common when spawning.	6, 7, 13, 14, 16, 18

Table VI-18 (Continued)

Group	Common Name	Abundance	Life History Type				Seasonality	Location	Preferred Habitat Type	Utilization of Site				Comments	Reference	
			Eggs	Larvae	Juveniles	Adults				Resident	Anadromous	Spawning	Nursery			Resource Value
Salmon and Trout	Northern Anchovy	4	X	X	X	X	seasonal-most mature adults leave in June-July, return in Sept.; larvae and juveniles have been collected all year, few adults in winter	Throughout the Bay in scattered schools concentrated in channels at low tides. Large schools from Simpson Pulp Mill to N of Samoa Bridge on incoming tide or from entrance of Bay to shallows of South Bay.	DTS, STS			X	X	4,2	Distribution often dependent on tide stage.	9
	Coho Salmon	3			X	X	seasonal-adults enter streams Sept-Dec; downstream migrates from April to Oct; peak in early June; small number of fish remain year-round	Adults during spawning migration in creeks and rivers in Humboldt Bay. Most in Mad River. Fry and fingerling in creeks and river for about 1 year after emergence. Remain in Humboldt estuary and Lower Mad River for a few days to a few months. Non-migratory adults most often found near Bay entrance.	TCSFW, CR		X	X	X	4,3	Abundant in coastal waters. Freshwater Creek stocked with fish from the Mad River hatchery. Mad River stock both from natural and hatchery production. Spawning peaks during high water flows, drought conditions result in poor runs.	4, 8, 10, 16, 19, 21
	Chinook Salmon	2			X	X	seasonal-adults enter streams August-November, downstream migrants in late spring	Only in Mad River. Fry and fingerling remain in fresh water for a few days to one year. Occasionally collected as smolt and adults in Humboldt Bay. Majority of smolts remain in Mad River estuary for 1-1/2 months.	TCSFW, CR		X	X	X	4,3	No spawning in Humboldt Bay.	8, 10, 19, 21
	Steelhead Trout	2			X	X	seasonal-adults enter stream from Nov. through April; downstream migrants from April-Oct; small number reside year-round	Adults during spawning migrations in Jacoby Creek and Freshwater Creek. Most in Mad River. Fry and fingerling in fresh water for 1 to 3 years, usually 2 years. Length of time smolt remain in Bay is unknown.	TCSFW, CR		X	X	X	3	Much of Mad River stock augmented by hatchery production from the Mad River hatchery.	4, 10, 16, 19, 21
Smelt	Longfin Smelt	4	X	X	X	X	year-round as adults; larvae and juveniles most common during January and Dec.	Found throughout Humboldt Bay most common in channels near Indian Island and NE end of Arcata Channel. Uncommon in Eureka Slough. Probably occur in Mad River.	STS, CR	7	X	X	X	4,3 2		3, 6, 16, 16, 17

Table VI-18 (Continued)

Group	Common Name	Abundance	Life History Type				Seasonality	Location	Preferred Habitat Type	Utilization of Site				Comments	Reference
			Eggs	Larvae	Juveniles	Adults				Resident	Anadromous	Spawning	Nursery		
	Eulachon	2	?	?	X	X	seasonal - as adults	Mad River, occasional reports from Humboldt.	CR		X	X	?	4,2	8, 21
	Surf Smelt	4	X	X	X	X	seasonal - as adults when spawning	Spawn in marine waters on exposed sandy beaches.	DTS, STS			X	X	4,3,2	3, 6, 14, 17, 21
Silver-sides	Topmelt and Jackmelt	2	X	X	X	X	year-round, spawn Oct-March; larvae from March-June	Arcata channel and Bay entrance South Bay, Arcata Oxidation Pond outlet.	DTS, MF, STS	?		X	X	2	6, 8, 14, 16
Cod	Tomcod	4			X	X	seasonal	Throughout Humboldt Bay, but concentrated in shallow channels.	STS	?			X	3	14, 16
Stickleback, Pipefish & Tubesnouts	Three-spine Stickleback; Tubesnout	3			X	X	year-round	Throughout Humboldt Bay in eelgrass beds, marshes, and around piling. Rare uncommon in Arcata Bay.	MF TCSSW CR	X		X	X	2, 0	14, 16
	Bay Pipefish	2			X	X	year-round-most common between Jan-March and Sept-Nov	Uniformly distributed in shallow waters and eelgrass beds throughout Arcata Bay and South Bay.	MF STS	X		X	X	3,2	14, 16
Surf Perch	Shiner	4			X	X	year-round	Throughout Bay except near the jetties in both shallow and deepwater, with and without cover. Abundant in upper Mad River Slough, NE Arcata Channel inside Eureka Slough. Very common in channel areas in Middle Bay.	DTS, STS, TCSSW, MF	X		X	X	3,2	10, 14, 15, 16, 34
	Pile	4			X	X	year-round	Present in low numbers throughout Bay, but avoid deep, open channels. Juveniles are around pier, reefs and jetties. Abundant in upper Arcata Channel and on east side of Indian Is.	STS, TCSSW, MF	X		X	X	3,2	10, 14, 15, 16

Table VI-18 (Continued)

Group	Common Name	Abundance	Life History Type				Seasonality	Location	Preferred Habitat Type	Utilization of Site				Comments	Reference
			Eggs	Larvae	Juveniles	Adults				Resident	Admro-	Spawning	Nursery	Resource Value	
	Striped	3			X	X	year-round	In mudflats and shallow channels as juveniles, around piers and jetties as adults. Usually absent in mid-channels. Common around rocks of South Jetty and the Fairhaven Boat ramp.	MF, STS (juv.) DTS, (adults)	X		X	X	3,2	10, 14, 15, 16
	Silver	2			X	X	year-round	In mudflats, beaches, piers, reefs, and jetties. Most common in shallow water with cover, but not around Eureka docks.	MF, STS	?		?	?	3,2	10, 14, 15, 16
	White	4			X	X	year-round, most common in June to September	Throughout Bay, but usually in deep water away from cover like pilings and eelgrass. Most common in Mad River Slough Channel, upper Arcata Bay and east side of Indian Island.	STS, TSCSW, DTS	X		X	X	3,2	10, 14, 15, 16
	Walleye	4			X	X	year-round, most common in summer and fall	In mudflats, sandy beaches and piers, but prefers shallow water. Most common on east side of Indian Is., Eureka Slough, and Upper Mad River Slough.	MF, TSCSW, TSCFW, STS	X		X	X	3,2	10, 14, 15, 16
	Redtail	2			X	X	year-round	Found near sandy beaches, piers, reefs, and jetties.	TSCSW, DTS	?		?	?	3,2	10, 14, 15, 16
Rockfish	All Species	3		X	X	X	year-round, larvae only in winter	Especially around riprap areas, shelves, piers and artificial reef. Most common in NE Arcata Channel and Eureka Channel, artificial reef and jetties. Not in sloughs.	DTS, STS (adult) MF (juvenile)	X		?	X	3,2	5, 6, 12, 14, 16
Greenling & Lingcod	Keip Greenling	3		X	X	X	year-round	Adults in reefs and jetties. Juveniles in mudflats and channels. Was most abundant species on artificial reef in South Bay.	MF, STS (juvenile) DTS (adult)	X		?	X		5, 6, 12, 14, 16
	Lingcod	2			X	X	year-round	Similar to Greenling. Greatest catch in Arcata Bay is southern portion of Arcata Channel north of Indian Island.	MF, STS (juvenile) DTS (adult)	?		?	X	4,3	6, 10, 14, 16

Table VI-18 (Continued)

Group	Common Name	Abundance	Life History Type				Seasonality	Location	Preferred Habitat Type	Utilization of Site				Comments	Reference	
			Eggs	Larvae	Juveniles	Adults				Resident	Anadromous	Spawning	Nursery			Resource Value
Sculpins	Pacific Staghorn Sculpin	4		X	X	X	year-round	Throughout Bay-in Arcata Bay, esp. common in southern part of Arcata Channel, E side of Indian Is. and Eureka Channel. Larvae very common in sloughs; demonstrates strong euryhaline tendency. Probably in the Mad River.	MF, TSCSW, TSCFW, CR, STS	X		X	X	3.2	Comprised a high proportion of the total larvae, juvenile and adult fish catch in Humboldt Bay.	6, 7, 14, 16, 17, 18
	Prickly Sculpin	3		X	X	X	year-round	Throughout Bay as larvae and juveniles but usually confined to upper portions of freshwater sloughs as adults.	MF, TSCSW, TSCFW, STS (juvenile) TCCFW (adult)	X		X	X	2		6, 7, 14, 16, 17, 18
	Buffalo Sculpin	4		X	X	X	year-round	Throughout Bay-with distribution as for staghorn sculpin.	TSCSW, STS	X		?	X	2	Abundant in trawl catch from Arcata Bay.	14, 16, 17
	Cabezon						X	year-round	Mount and inlet in Bay, over rocky areas.	DTS	?			?	3	
Poachers and Snailfish	All Species	1		X	X	X	year-round ?	Medium deep to deep channels usually on medium to large rock rubble. Poachers have been collected from Eureka and Southport Channels and South Bay; snailfish from Mad River Slough channel.	DTS, TSCSW	?		?	X	0		6, 14, 16
	All Species	1		X		X	year-round ?	Usually occur only near entrance to Bay.	DTS					3	Infrequent, individuals probably enter the Bay to feed.	6, 10
Seabass & Croakers	Bay Goby	3		X	X	X	year-round	Adults and juveniles in estuarine and brackish water areas, esp. in NE Arcata channel and upper Mad River slough. Also in other sloughs off Arcata Bay. Uncommon in South Bay.	MF, TSCFW, TSCSW, STS	X		X	X	2	One of the most abundant species taken as larvae and juveniles in Bay (42-49% of all forms taken). Strongly euryhaline.	6, 7, 14, 16, 17, 18
	Arrow Goby	?		X	X	X	year-round	Adults and juveniles in various locations on mudflats in Arcata Bay and the Bay inlet. Especially common in upper Mad River Slough, near Arcata Oxidation Pond and Eureka Slough.	MF, TSCFW STS, DTS	X		X	X	2	Commensal with the mud or ghost shrimp. Strongly euryhaline.	6, 7, 14, 16, 17, 18

Table VI-18 (Continued)

Group	Common Name	Abundance	Life History Type				Seasonality	Location	Preferred Habitat Type	Utilization of Site				Resource Value	Comments	Reference
			Eggs	Larvae	Juveniles	Adults				Resident	Shadrow	Spawning	Nursery			
Flatfish	Wolf-eel	1				X	year-round	Rocks and jetties near the Bay inlet.	DTS	?				0	The only large eel-like species in the Bay.	10
	Prickleback	1				X	?	Medium rocks and eelgrass beds, South Bay only.	MF, STS	?				0		3, 10, 14
	Gunnel	2				X	year-round	Throughout Arcata Bay, uncommon in South Bay. Most from lower Arcata and Eureka Channels. None in upper Mad River Slough; few in Eureka Channel.	MF, STS, DTS	?				2	Common on areas with medium-high wave exposure. Vegetated areas with fine sediments are preferred.	10, 14, 16
	Pacific Sandlance	2		X	X	X	year-round	Throughout Bay, probably most common on sand flats and in all channels. Not on muddy bottoms.	DTS, STS	?		?	X	2		6, 7, 14, 16, 17
	Sanddabs	4		X	X	X	year-round	Throughout Bay, not in freshwater sloughs. Catch in Arcata Bay greatest in Eureka and Arcata Channels, north of Indian Island and North Bay Channel.	MF, STS, DTS	X		X	X	4, 3 2		6, 10, 14, 16, 34
	English Sole	4	?	X	X	X	year-round	Throughout Bay - most common in mid-channel trawls, mouth of Eureka Slough, north and east of Indian Is.; Eureka, Samoa, and North Bay Channels. Initial benthic stages in intertidal areas, concentrated in Southport Channel and northern portion of Arcata Bay. Young plentiful over mud with eelgrass cover and on mats of Ulva sp. near channel edges. Larger juveniles shift to Hookton Channel and deeper water in Mad River and Arcata Channels.	MF, STS, DTS	X			X	4, 3 2	One of the most abundant fish in Humboldt Bay, with catches often exceeding all other species.	6, 9, 16, 34
	Starry Flounder	3		X	X	X	year-round	Most of Bay and probably lower portions of Mad River. Common in shallow channels and sloughs; especially Eureka and upper Mad River Sloughs.	STS, TCSSW, TCSFW	X		X		4, 3 2		3, 10, 11, 16

P. INVERTEBRATES

Invertebrates that inhabit Humboldt Bay can be grouped conveniently into categories that are not strictly taxonomic. Each of the major groups contain animals that are distinguished by their general morphology, habitat and/or function in the faunal community. Table VI-19 lists the major invertebrates groups, beginning with the most primitive forms (sponges) and proceeding to the most complex (echinoderms); a brief description of their general habitat in Humboldt Bay is also included (from Hedgpeth, et al., 1968; Monroe, 1973; Smith and Carlton, 1975). It should be noted that certain members of the various groups may be found only occasionally in the bay or during certain periods of the year.

Three of the groups are particularly important because of their direct or indirect economic importance. These include large decapod crustaceans (crabs and shrimp) and pelecypods (bivalves) which are exploited by commercial and sports fishermen. Copepods are small crustaceans and constitute the largest basal group in marine food chains and comprise the bulk of the zooplankton that fish, and many other estuarine animals, utilize for food. Shellfish will be discussed in considerable detail elsewhere in this section.

Polychaetes and gastropods contribute substantially to the total invertebrate biomass and diversity in Humboldt Bay. Members of the remaining groups are less significant because of their relative scarcity, extremely small size, or their infrequent appearance inside Humboldt Bay. Nevertheless, no species can be considered irrelevant because of these characteristics. Given the complexity of estuarine communities, the importance of all species must be assumed.

Appendix E, Table E-2, lists all the invertebrate species that have been reported in Humboldt Bay (from Carrin, 1973; DeWees and Gotshall, 1974; Dykhous, 1976, Hedgpeth, et al., 1968; Lambert, 1973; McBee, 1971; Monroe, 1973, and PG&E, 1973). This list is unquestionably incomplete; for example, one would expect to find many nematode (round worm) species in sand and mud flats in the bay, yet none have been described. Future studies would be expected to add substantial numbers of species to the list. It should also be noted that many of these species normally inhabit neritic* waters along the open coast and thus, reports on such species in Humboldt Bay must not necessarily be interpreted to mean they are normal inhabitants of the bay. Humboldt Bay is a somewhat atypical estuary; because of its shallow structure, the tidal prism of the bay is large in comparison with its low tidal volume (Skeesick, 1963). Thus, ocean water conditions greatly affect the water characteristics within the bay and

*Neritic - ocean environment between the shore and the edge of the continental shelf, includes both the water column and the bottom.

TABLE VI-19

Major Groups of Humboldt Bay Invertebrates

<u>Invertebrate Group</u>	<u>General Habitat(s)</u>
1. Sponges	Encrusted on rocks
2. Hydroids	Attached to pilings, rocks, shells and eel grass
3. Jellyfishes	Conspicuous forms are free swimming; not common in the bay
4. Sea Anemones	Attached to rocks and submerged timbers
5. Ctenophores (Comb-jellies)	Float on the surface; rarely found in the bay
6. Nemerteans (Ribbon worms)	Burrow in mud flats; found under rocks or among algae
7. Phoronids (Plume worms)	Inhabit tubes on pilings, rocks, or in mud flats
8. Polychaetes (Bristle worms)	Inhabit tubes on rocks, pilings, shells, etc.; burrow in muddy sand
9. Sipunculids (Peanut worms)	Burrow in mud flats
10. Echiurids (Spoon worms)	Burrow in mud flats
11. Copepods	Drift or swim in water column
12. Barnacles	Attached to rocks, pilings, pipes or shells
13. Cumaceans and Cheliferans	Burrow in mud flats; inhabit mussel beds
14. Amphipods	Inhabit water column, mud, hydroid colonies, eel grass
15. Isopods	Inhabit sand burrows, live on rocks and in pilings
16. Decapods	
a. ghost & mud shrimps	Burrow in mud flats
b. shore crabs	Inhabit sandy or rocky beaches
c. large crabs	Prefer sandy bottoms
d. market shrimps	Prefer sand bottoms; not common in the bay
17. Arachnoids	Inhabit high beaches; larvae may be found in marshes
18. Pycnogonids (sea spiders)	Inhabit mussel beds, eel grass beds, hydrois colonies
19. Gastropods	
a. limpets	Live on intertidal rocks
b. nudibranchs	Live among rocks in protected intertidal areas
c. periwinkles, snails	Live on intertidal rocks
d. chitons	Live on intertidal rocks
20. Pelecypods	
a. mussels & oysters	Attached to hard substances (rocks, shells, pilings)
b. clams	Buried in soft substrates (sand, mud)
c. burrowing clams	Burrow in pilings, rocks, concrete, etc.
21. Octopods	Live among rocks
22. Bryozoans (Moss animals)	Attached to rocks, shells, pilings and eel grass
23. Echinoderms	Inhabit rocky areas or in softer bottoms in the bay

also, the invertebrates that are generally confined to ocean waters may often be found in Humboldt Bay, particularly during the summer when water conditions in the bay are almost identical to ocean waters. After the onset of winter rains, the salinity of bay waters decreases and those invertebrate species that cannot tolerate reduced salinities would be expected to either migrate out of the bay or suffer substantial seasonal mortalities. Nevertheless, it is felt that Table E-2, Appendix E, represents a reasonably accurate and complete list of the major Humboldt Bay invertebrate species. Table E-3, Appendix E, includes recent changes in the names of species reported in the earlier literature.

A brief discussion of the general significance of each invertebrate group is included in the following pages. Only major species are described.

Sponges. No sponges of commercial value are found in or near the bay. Adult *Haliclina* spp. are attached plankton feeders and their larvae are occasionally a minor zooplankton component.

Hydroids. Hydroids are small, plant-like organisms with delicate beauty. They have flower-like heads attached to a stalk and are generally not recognized by laymen despite their belonging to the same taxonomic group as the jellyfishes and sea anemones. They provide a protective forest for numerous small animals in a variety of habitats. *Tubularia crocea* grow in large clumps on submerged floats or piles while *T. marina* grow on rocks along the shoreline. *Vellela lata* has a triangular "sail" to keep it afloat and often accumulates in considerable windrows along the beach. Adult hydroids are active carnivores that feed on zooplankton while the larvae are a minor plankton component.

Jellyfish. These large organisms are frequently found stranded on the beach, yet are rarely found in the bay although *Aurellia* sp. may often be found there during the summer. *Pelagia* sp. and especially *Chrysaora* sp. may cause considerable pain if handled while alive. The adults feed on plankton and small animals; larvae are occasionally found in small numbers in plankton tows.

Sea anemones. The large flower-like anemones live in the tide pools along rocky shores and thickly covered pilings in areas of high salinity. *Anthopleura xanthogrammica* is one of the largest anemones in the world, but is rarely found in bays; *A. elegantissima* is the most abundant anemone on the coast and thrives inside bays (Hedgpeth, et al., 1968). *Cerianthus* sp. is a burrowing form found on mud flats. Adult anemones are predators of large plankton and small fish and often act as scavengers. Larvae are a minor plankton component.

Ctenophores are small, jellyfish-like, transparent spheres that float at the surface of the ocean and only occasionally are encountered in the bay while alive.

Nemertean worms. This group consists of long, slender, flat worms which are often brilliantly colored. They possess a unique eversible proboscis which, in *C. californiensis* may be longer than the animal itself. The adults are active predators of small animals and the larvae are a minor zooplankton component.

Phoronid worms. These are rare, worm-like organisms with generally orange plumes, that have gelatinous bodies protected by a tube that is buried in the mud. *Phoronopsis viridis* is green-plumed and sometimes carpets the mud with a green fuzz. Colonies of these stringy worms are common in estuary fauna. Adults are plankton feeders and larvae are a minor plankton component.

Polychaetes are generally among the most abundant and significant animals in the bay. There are many species in shallow, sandy bottoms and in intertidal mud flats. Polychaetes are elongated worms with bodies divided into numerous segments. Many are pelagic at times, but most of them build tubes to live in. Some of the tube dwellers live in mud and sand, forming tubes consisting of: mucous and sand; mucous in matted clumps of seaweed; tough parchment-like material; or limy materials on rocks, shells, or kelp. *Nereis* sp. are found among the barnacles and mussels on wharf piles, on gravelly beaches and under rocks. Lugworms live in burrows in mud flats and *Glycera americana* live among roots of eel grass.

Although they are common in the bay, their secretive habits result in their being overlooked by casual observers. Studies by PG&E (1973) showed that polychaetes made up 43.7% of the total organisms in all benthic samples in 1971 and 1972. *Glycera tenuis* and *Hemipodus borealis* were the most widely distributed polychaetes in Humboldt Bay.

Polychaetes include a wide variety of feeding types and include plankton feeders, carnivores that feed on small animals of all sorts, species that eat seaweeds and others which extract organic materials from swallowed sand and mud. There are typically large numbers of polychaete larvae in plankton samples. Adults are commonly used as bait by sports fishermen.

Sipunculid worms. Peanut worms may be found in burrows in firm sands, mud, or among eelgrass roots. *Goldfingia agassizi* is an abundant, rough-skinned worm that burrows in the muddy crevices between rocks. Adult sipunculids are mostly deposit feeders and filter sand and silt. Larval peanut worms are a minor zooplankton component.

Echiurids are fairly large, robust, wormlike organisms that are common in mudflats. They are highly specialized and *Urechis caupo* is involved in an unusual symbiotic relationship with a scale worm, pea crab and a goby (Hedgpeth, et al., 1968). Adults live in burrows and filter microscopic food through a slime net.

Copepods exist in the marine environment in such abundance that, although they are very small, they form the principal food supply of many much larger animals. On the basis of yearly totals, 43.4% of all zooplankton collected during 1971 and 1972 in Humboldt Bay were adult copepods (PG&E, 1973).

Barnacles are found in great numbers in all bays (Hedgpeth, et al., 1968). They are a prominent member of the fouling community and any solid object that has been in the bay for any length of time will be encrusted with them; wharf piles below high water are often covered entirely. There are two kinds of fixed barnacles, goose (*Lepas* sp. and *Pollicipes* sp.) and acorn barnacles (*Balanus* spp. and *Chthamalus* spp.) Goose barnacles are stalked and they attach to rocks, wood and to each other. Acorn barnacles such as *Balanus glabrata*, one of the commonest animals in the bay, are attached directly to objects and encrust on rocks, shells, wood, pipes, largae algae or other suitable substances. The adults are attached plankton feeders. Barnacle larvae are the most abundant plankters in Humboldt Bay, accounting for 48.3% of all zooplankton collected in 1971 and 1972 (PG&E, 1973).

Cumaceans and Cheliferans are small shrimplike organisms. Cumaceans are found in mud or silt bottoms where they act as scavengers while cheliferans are especially common in mussel beds or clusters of hydroids and bryozoans.

Amphipods are one of the most abundant and, at the same time, least studied populations of estuarine animals. Amphipod species occupy a variety of habitats including tubes of soft mud, pilings in the bay and wherever algae or bryozoans are found on rocks or pilings. The large *Caprella californica* may be found on eel grass in the bay. *Paroediceroides* sp. was the most numerous and widely distributed benthic taxa sampled in 1971 and 1972 (PG&E, 1973). The adults are generally scavengers and feed on organic debris; a small number are predators of small animals. The gammarids are a common planktonic form and are consumed by fish.

Isopods are small, rather inconspicuous forms that usually are found under boards in damp places along the beach. Some isopods feed on debris in the water while others are predaceous. Of potential concern is *Limnoria* sp., a wood borer that attacks pilings at all levels and can cause a great amount of damage and the ultimate destruction of the pile (e.g. Hedgpeth, et al., 1968). Although *Limnoria* sp. has been reported in Humboldt, its abundance and distribution has not been studied.

Decapods have been organized into the following categories:

- . Ghost and mud shrimp live in burrows in mudflats. *Ubogobia pugettensis* is found in holes a foot or more in depth in the lower intertidal or subtidal areas. *Callinassa cali-*

forniensis live in branched burrows in the upper intertidal area. They both feed by extracting detritus, primarily bacteria, from a continuous stream of mud which passed through their digestive tracts. Their constant burrowing in the mud flats make them undesirable pests on oyster and clam beds. Both species are utilized as bait by fishermen.

- . Market shrimp. *Pandalus danae* is a commercially-important, large shrimp that lives in deep water and would not be expected to be found commonly in the bay. *Crangon nigricauda* is one of the common market shrimp in California, along with several other *Crangon* sp. that generally live in deeper water. They are, however, commonly found in Humboldt Bay. (P. McLaughlin, California Fish and Game, personal communication.)
- . Other shrimp. *Hippolyte* sp. is the common green shrimp that make up great congregations swimming in eelgrass beds. *Spirontocaris paludicola* and *S. picta* are found on mudflats and eelgrass beds. Like most shrimp, they are scavengers and feed on organic debris.
- . Shore crabs. *Hemigrapsus nudus* is found along rocky beaches and gravel shores while *H. oregonensis* prefers beaches where there is some mud. Both species are important scavengers in the intertidal community.
- . Large crabs include those crabs that are utilized as a food resource. *Cancer magister* is one of the largest edible crabs on the Pacific coast. They are commonly found in markets and sustain a large fishery outside of Humboldt Bay. *C. productus* is also large and along with *C. magister* is utilized by sports fishermen. *C. productus* is not, however, plentiful enough to sustain a commercial fishery. Both species prefer sandy or rocky bottoms and are carnivorous, particularly *C. productus*, or act as scavengers. *C. antennarius* is a large, edible crab but is seldom utilized because of the difficulty of obtaining sufficient numbers from the rocky coast it inhabits. The larvae of all crabs are an important zooplankton component in the bay. Humboldt Bay is also an important nursery area for *C. magister*, *C. productus*, and *C. antennarius*. Intertidal mudflats, particularly those areas heavy with eelgrass growth, provide cover and feeding ground for large numbers of juvenile crabs. As they grow larger, these crabs move to deeper channels and eventually migrate out of the bay.
- . Other crabs. *Emerita analoga* are relatively large (1 inch), occupy sandy beaches and are a food source for birds. *Pachygrapsus crassipes* live in rocky intertidal areas and are perhaps the most important scavengers in the habitat.

Petrolisthes sp. are small, flat crabs that live under rocks and also serve as scavengers. It is noted that its flat shape makes it useful for embedding in blocks of plastic prior to selling it as a curio. Hermit crabs (*Pagurus* sp.) are unique because they inhabit unoccupied gastropod shells. They, too, are found in rocky areas and are important scavengers. *Pugettia producta* is commonly seen crawling around seaweed or clumps of eelgrass; their bodies are usually covered with hydroids and bryozoans. *Pinnixa* sp. are typically found in tubes of polychaete worms or in the mantle cavity of gaper clams. It is not certain how they obtain their food. The larvae of all these species are zooplankters.

Arachnids. Adult spiders, ticks and mites are occasionally found in the high intertidal zone, especially in marshes and swamps. *Halobisium occidentale* is common in debris-littered mudflats in the bay. Larval arachnids may be of minor importance in shallow water food webs.

Pycnogonids generally live among seaweeds, bryozoans and hydroids, in tide pools and among clumps of mussels and sea anemones on pilings. Adults feed on zooplankters and larvae are a minor plankton component.

Gastropods can be placed into categories that reflect differences in their structure, habitat, or method of feeding.

- . Limpets occur in great abundance on rocks in different intertidal zones. They are generally similar in appearance and eating habits--all are algae scrapers. *Acmaca digitalis* is the commonest species on rocks in high intertidal areas. They are found along open and protected waters and are very hardy, being able to tolerate mud, debris and even sewage and industrial pollution. *A. pelta*, *A. paradigitalis* and *A. scutum* occupy different intertidal zones on rocky beaches along protected waters. *A. scabra* and *A. persona* occupy the uppermost intertidal areas and are found on rough rocks, deep crevices among rocks or on roofs of caverns. Limpet egg cases and larvae are often found in the zooplankton.
- . Nudibranchs are beautifully colored gastropods that do not have a shell, yet are prized by collectors. They are generally found on algae in tide pools or on kelp further from shore, although *Aglaja* sp. may be found on estuarine flats. They normally graze on plants, however, some prey on hydroids (e.g. *Hermisenda crassicornis*).

- . Periwinkles and snails. Periwinkles are small, drab snails, with spiral shells, that occupy the highest rocks in the intertidal zone. They are always well-removed from the sea and often occur in groups. *Littorina planaxis* represents an extreme high water form that is found up to 20 ft. above the high tide line. *L. scutulata* is commonly found on rocks and pilings in bays, a characteristic that distinguishes it from other *Littorina* sp. The larger snails, *Calliostoma* sp., *Thyas emarginata* and *T. lamellosa*, characteristically inhabit rocky shores where they graze on algae. Olive snails live under the surface on sandy bottoms or in beds of eelgrass. *Olivella biplacata* is very common in Humboldt Bay. *Tegula* sp. occupy crevices or rocks in the intertidal zone.
- . Chitons are found on or underneath rocks in intertidal areas with *Katherina tunicata* being the most abundant. Most are herbivores or omnivores.
- . Predacious snails. *Nassarius fossatus* is the commonest of the large, predacious snails and is found on suitable mud flats or in eel grass when laying eggs in the summer. *Ocenebra japonica* is an oyster predator that was introduced from Japan in shipments of oyster seed, but is apparently not abundant in Humboldt Bay. *Pellicipes lewisii* is a clam predator that burrows in mud flats. It forces the valves of its prey open or drills a small hole and severs the muscle. It also serves as a scavenger. The eggs and larvae of all these species provide food for fish and shellfish.

Pelecypods or bivalves such as clams, mussels, and oysters are the most economically-important invertebrate group in Humboldt Bay.

Extensive clam beds exist throughout most of the intertidal areas of the bay with several species of clams occurring subtidally as well. Table VI-20 lists the shellfish species found in Humboldt Bay that are utilized by commercial and/or recreational shellfishermen (from Fitch, 1953; Machell and DeMartini, 1971; Monroe, 1973; Stout, 1967; U.S. Corps of Engineers, 1973).

The clam species most commonly utilized are, in order of importance, gapers (*Tresus* sp.), Washingtons (*Saxidomus giganteus*), littlenecks (*Prototheca staminea*), cockles (*Clinocardium nuttalli*), and softshells (*Mya arenaria*).

Gaper clams are abundant throughout South Humboldt Bay with lesser numbers in localized sites in Arcata Bay. These clams are the object of a heavy sports fishery that takes place in intertidal areas with sand and mud bottoms. Washington clams are widely

Table VI-20

ECONOMICALLY IMPORTANT SHELLFISH INSIDE HUMBOLDT BAY

<u>Species</u>	<u>Common Name</u>	<u>Abundance</u>	<u>Importance</u>
CLAMS AND COCKLES			
<i>Clinocardium nuttalli</i>	Basket cockle	Common	Sports fishery - food
<i>Mya arenaria</i>	Soft shell clam	Abundant	Sports fishery - food
<i>Panope generosa</i>	Geoduck	Scarce	Sports fishery - food
<i>Prototheca staminea</i>	Pacific littleneck clam	Common	Sports fishery - food
<i>Saxidomus giganteus</i>	Smooth Washington clam	Abundant	Sports fishery - food
<i>Saxidomus nuttalli</i>	Common Washington clam	Common	Sports fishery - food
<i>Siliqua patula</i>	Northern razor clam	Scarce*	Sports fishery - food
<i>Tapes semidecussata</i>	Japanese littleneck clam	Scarce	Sports fishery - food
<i>Tresus apax</i>	Gaper clam	Common	Sports fishery - food
<i>Tresus nuttalli</i>	Gaper clam	Abundant	Commercial and sports fishery - food
<i>Venus mercenaria</i>	Quahog	Scarce*	Sports fishery - food
<i>Zirfaea pilabryi</i>	Rough piddock	Scarce	Sports fishery - food
MUSSELS			
<i>Mytilus californianus</i>	California sea mussel	Scarce	Sports fishery - food, bait
<i>Mytilus edulis</i>	Bay mussel	Abundant	Sports fishery - food, bait
<i>Velosella recta</i>	Giant horse mussel	Very scarce*	Sports fishery - food
OYSTERS			
<i>Crassostrea gigas</i>	Giant Pacific oyster	Abundant	Commercial fishery - food
<i>Crassostrea virginica</i>	Eastern oyster	Scarce*	
<i>Ostrea lurida</i>	Native (Olympia) oyster	Common	Sports fishery - food
SCALLOPS			
<i>Hinnetes multirugosus</i>	Rock Scallop	Scarce	Sports fishery - food

*It may be questioned whether or not these species should be considered as normal inhabitants of Humboldt Bay.

distributed throughout South Bay and are also found in North Bay. The largest population is located near Field's Landing where it is capable of supporting a minor sports fishery. Littleneck clams are generally confined to South Humboldt Bay, although there is one small population in Arcata Bay (Stout, 1967). Small littleneck beds can be found wherever there is an intertidal bed of cobbles especially near the mouths of creeks and in cleaner sand and sandy mud. Cockles are distributed throughout the western half of Arcata Bay and south of Field's Landing in South Humboldt Bay. There is one small population of softshell clams in South Humboldt Bay and somewhat greater numbers in the low salinity areas of northeast Arcata Bay (Monroe, 1973).

Plate 13 shows where the various clam species are found in Humboldt Bay; Plate 25 indicates the general location of commercial oyster beds and the potential lease area boundary for private oyster growing (U.S. Army Corps of Engineers, 1973; Frank Douglas and Ted Kuiper, personal communication).

Humboldt Bay, as of 1959, had seven shellfish reserves. These are areas of state land that were established by the State for clam digging and native oyster fishing. For a detailed discussion of these reserves see the Refuges and Reserves Profile.

The history of oyster culture in Humboldt Bay is quite interesting and informative (Barret, 1963; Monroe, 1973). There have been numerous attempts to raise eastern oyster (*C. virginica*) beginning late in the nineteenth century. Subsequent plantings were made in 1910 and from 1935 to the early 1940's. In all cases, the oysters failed to grow and survive for reasons that are not known. It is not entirely clear whether or not this species is still found in the bay, even though it is included on contemporary species lists (e.g. Monroe, 1973). In the 1930's, attempts were made to develop a commercial oyster industry utilizing the small native oyster, *Ostrea lurida*. However, because of its small size and overexploitation, that fishery quickly declined. Finally, during the mid-1950's, Pacific oysters were introduced into the bay and a successful oyster industry has thrived since that time.

There are three burrowing pelecypod species found in the bay. The giant northwest shipworm, *Bankia setacea*, is found in exposed pilings and wharfs in higher salinity areas. They are remarkably efficient wood borers that usually operate near the mud line. A heavy infestation by this shipworm will reduce a new, untreated pile to the collapsing point in 6 to 12 months and creosoting will prolong the life of the pile by only 3 to 4 years. *P. penita* drills into solid rock along shores in protected areas. In some locations they are sought as food when they occupy softer substrates such as sandstone. *Zirfaea pilsbryi* is the largest of the rock borers (up to 4-1/2 inches) and is found on rocky reefs and in protected mud and clay. They are also utilized for food by a limited number of shellfishermen.

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SPAWNING AREAS & SHELLFISH BEDS

PLATE NO 13 NORTH

LEGEND



Heavy Herring Spawning



Clams



Salmon & Trout Streams or
Rearing Areas



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Barrett, 1963
Bonnett, 1936
Monroe, 1973
Rabin, 1976
George Allen (PC)
Roger Barnhart (PC)
Karen Gietzel (PC)
Ron Warner (PC)



SPAWNING AREAS & SHELLFISH BEDS

PLATE NO 13 SOUTH

LEGEND



Dungeness Crab



Clams



Salmon & Trout Streams or
Rearing Areas



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source Barrett 1963
Bonnett 1936
Monroe 1973
Rabin 1976
George Allen (PC)
Roger Bernhart (PC)
Karen Gietzel (PC)
Ron Warner (PC)

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Most of the remaining pelecypods are small clams found in the bay. *Macoma nasuta* occurs in mudflats and is probably the most common clam in this habitat. They can be eaten but are not widely utilized. *Pododesmus macroschismus* is found on rocks but is most common on wharf pilings. They have an excellent flavor but are probably very scarce in Humboldt Bay. *Tellina bodegensis* is a large (up to three inches) common sand flat clam that feeds on plant detritus and diatoms. *Tagelus californianus* is abundant on mudflats as are other *Macoma* spp. *Gemma gemma*, *Lyonsia californica*, *Transennella tantilla* and *Solen sicarius* occur on mud or sand flats and may be common in eelgrass beds. Most clams are filter feeders and their larvae are sporadically found in zooplankton.

Bryozoans are similar to hydroids in their appearance and habitat. They occupy rock crevices in lower intertidal zones where they provide shelter to hosts of small animals. *Flustrella cervicornis* is probably the most common species in the bay.

Echinoderms would typically be expected to occupy habitats outside the bay. However, because of the routine of tidal flows in Humboldt Bay, several species may be found inside the bay. *Pisaster brevispinis* occurs on soft mud or sand bottoms, eel grass and on wharf piling inside the bay. The large *Pycnopodia helianthoides* is found on rocks in low intertidal areas; they feed on sea urchins and worm snails. *Pisaster ochraceus* also is found on intertidal rocks but feeds on chitons, barnacles and limpets. Sea urchins (*Strongylocentrotus* sp.) are found among rocks in intertidal areas as are *Eupentacta quinquesemita*. *Dendraster excentricus* may occur in large numbers on deep water sand flats where they scour for edible diatoms. The larvae of all these species are occasionally found in zooplankton.

Invertebrate Habitats within Humboldt Bay

There have been few systematic studies to determine the distribution, abundance and location of the various invertebrate species within Humboldt Bay. Table VI-19 can be used as a general guide to indicate where major groups are most likely to be located in the Bay. Appendix E includes a description of the habitats for many individual species (Smith and Carlton, 1975). However, substantial amounts of information, which can be obtained only by conducting careful surveys, are necessary in order to describe the habitats occupied by invertebrate species in Humboldt Bay.

Carrin (1973) described the invertebrate species found in different habitats in Arcata Bay along the Mad River Channel. Specifically, he identified several different substrate types and noted the distribution of invertebrates with or upon each substrate. Rocks, mudflats, sandy substrates, and pools within the eelgrass beds were the habitat types he described.

Shore rock crabs (*P. crassipes*) and masked limpets (*A. persona*) were found on concrete and boulders located at the high water mark along with an isopod (*N. oregonensis*) which was abundant under the rocks. Scattered bay mussels (*M. edulis*), numerous amphipods (*A. angustus*) and checkered periwinkles (*L. scutulata*) were found on rocks somewhat lower in the intertidal zone. Barnacles (*B. glandula*) were extremely abundant on rocks in this area. Yellow stone crabs (*H. oregonensis*) were common where the dike and mudflat met. Mudflats adjacent to dikes also supported populations of soft shell clams and native oyster, the latter usually in water-filled pools.

Pools situated in eelgrass (*Zostera marina*) beds were occupied by several species of shrimp including *S. paludicola*, *S. picta*, *C. nigromaculata* and *Hippolyte* sp. Several amphipod species were also abundant, sharing these pools with cheliferans (*L. dubia*) and other invertebrates. On mudflats where there was an even distribution of *Zostera*, numerous amphipods and some gastropods (*P. taylori* and *H. smithi*) were found. *L. dubia* was the dominant interstitial mud species along with the ubiquitous small clam, *T. tantilla*. Birds feeding in the area were observed feeding on a long polychaete worm, *N. tenuis*.

On sandy substrates, burrowing species such as the fat innkeeper, *U. caupo*, and the shrimp, *U. pugettensis* and *C. californiensis*, were abundant. Bivalve molluscs, including old Pacific oysters, California sea mussels, Common littlenecks and gaper clams were found near the south end of the study area, closer to the bay entrance.

Boyd, et al., (1975) identified and described the distribution of benthic communities in North Bay, Samoa, and Eureka Channels during September-November, 1974, and Entrance Bay during December, 1974, and January, 1975.

The Eureka-Samoa assemblage was characterized by four species of polychaetes (*C. ambiseta*, *Lysilla* sp., *H. elongatus* and *S. Longicornis*), three mullosc species (*H. californica*, *M. nasuta* and *M. tumida*) and a cumacean (*D. dawsoni*). These species occurred in shallow water associated with sediments relatively high in silt and clay.

The North Bay Channel assemblage was characterized by four polychaete species (*A. williamsi*, *H. elongatus*, *O. magna* and *P. socialis*), four molluscs (*A. diegensis*, *Alvinia* sp., *C. nuttalli* and *M. inquinata*) and a caprellid amphipod (*T. pilimana*). All these species occurred in deeper waters and were associated with sediments containing more than 50% sand. Sediments of this character are apparently confined to the central portion of Humboldt Bay, extending from just south of Eureka to near Fields Landing. The largest number of organisms per sample were found within the North Bay Channel area.

1

The Entrance Bay assemblage had relatively few invertebrate species and low numbers of organisms per sample. Two polychaetes (*G. tenuis* and *G. polygnatha*) and four molluscs (*N. fossatus*, *O. biplacata*, *O. pycna* and *T. nuculoides*) characterized the fauna in this area.

Boyd, et al., (1975) felt that there was some sort of relationship between the abundance and location of benthic invertebrates and their relation to the main channels. Samples on the western side of the channels showed the greatest diversity followed by samples in the main channels; samples collected along the eastern side of the channels had the lowest diversity. They suggested that this pattern was related to sediment transport mechanisms operating along the channels. Areas adjacent to channels on the eastern sides are eroding gradually, while areas to the west of the channels are slowly aggrading. The channel bottom stations were not significantly different from those in the western channel flank. The less diverse eastern channel flanks indicate that erosional processes have been instrumental in restricting the establishment of diverse communities along these eastern flanks.

Benthic organisms in North Bay Channel from its juncture with the Eureka and Samoa Channels to Elk River appeared to exist in muddy sands. The least diverse group of stations were in Entrance Bay. The coarse sediments indicate a dynamic bottom environment that can be colonized by only a few species.

Q. REPTILES AND AMPHIBIANS

Very little information is available on the reptiles and amphibians of the Humboldt Bay area in spite of the fact that herpetologists and natural historians have been collecting there since before the turn of the century. Local biologists have a good feeling for the natural history of members of this group but have not published their observations in accessible form. Species of this group have not been popular subjects of research by Master's candidates at Humboldt State University. The information presented here is based on the work of Stebbins (1966, 1972) supplemented by inspection of museum records. Distributional information given by Stebbins may be liberal in assigning species to the study area. On the other hand, the absence of collected specimens cannot be taken as evidence that a species does not occur in an area. Hence, these two information sources probably provide high and low estimates for the number and identity of species in the study area. Similar groups of species are discussed in the following sections.

Newts and Salamanders

Newts and salamanders are unobtrusive, often even to the experienced collector; and their abundance is usually underestimated. They feed on arthropods found under logs and rocks, and in litter and soil. Studies of the role of salamanders in energy flow and nutrient cycling in an eastern deciduous forest (Burton and Likens, 1975) have indicated that while populations of these species do not account for as much energy stored or transferred as birds and mammals, they are very efficient at producing tissue with high protein content from ingested food and hence are more productive in this regard than birds or mammals. Salamanders may also play a critical role in the regulation of invertebrates responsible for the breakdown of litter. The potential influence of these species should, therefore, not be underestimated.

The diversity of salamander species in the Humboldt Bay area is higher than in most other regions of the western United States. Generally, high amphibian diversity is found only east of the Mississippi. The wet climate of northwestern California and the abundance of mesic habitat situations in wetland areas has probably been influential in permitting the origin and presence of the number of species known or strongly suspected to occur in this area.

Frogs and Toads

Eight species and subspecies of frogs and toads are likely to occur in the study area. Frogs live in and on the margins of still or slowly flowing bodies of water and are generally intolerant of saline or brackish waters. Toads can persist for quite long

periods away from water as long as their microhabitat provides shade and moisture. Both groups of species feed on arthropods, primarily insects, flying near the ground or occurring on the surface or in the litter.

Turtles

The study area, along with the rest of the western United States, has little in the way of a turtle fauna. One species is expected to occur here on the basis of distribution maps, but records are not available in the collection of the museum at Humboldt State University.

Lizards and Skinks

One species of skink and five species of lizards have been recorded from the study area or are expected there on the basis of habitat preference and records in the county. Spiny lizards are typically found in grassland, shrub habitat, or open woodland, around rocks and weed patches where they bask on warm days. Alligator lizards are more characteristic of shady situation in shrub habitat or woodland; they rest under logs or rocks and feed primarily on insects found in the litter. Skinks are most commonly found under cover objects, such as logs and probably feed on arthropods in soil and litter.

Snakes

Snakes recorded from the area or similar habitat in the country include boas, ringnecks, racers, gopher snakes, kingsnakes, garter snakes, and the northern Pacific rattlesnake. Most of these species are typically found in grassland, shrub, or woodland situations where ground cover is relatively dense. Garter snakes occur in both aquatic and terrestrial situations. Rattlesnakes prefer sunny or warm conditions in close proximity to cover. The principal food of smaller species is arthropods (largely insects); mammals and young birds may be eaten by larger species. The rattlesnake feeds almost exclusively on warm-blooded vertebrates, principally small mammals.

Habitat Use by Reptiles and Amphibians

Habitat use by members of these groups of vertebrates is relatively restricted in comparison with that of birds and mammals. Terrestrial species are most prevalent in woodland situations or in

areas of shrub, grass or agricultural use where cover is available and dessication is not a problem. No species found in the study area are known to be capable of dealing with the saline conditions found in salt or brackish marshes.

No information specific to habitat use by reptile or amphibian species in the study area is available. The following summaries are based on general knowledge of the species involved as represented in Table E-6 (Appendix E).

Urban areas are occupied by few species of herps; about 4 species may be found in such situations around Humboldt Bay. The slender salamander may be found in backyards and gardens or in packs under trees where litter has been allowed to accumulate. The fence lizard may occur on fences or rock walls near vegetated areas. Garter snake species may appear in backyards or weedy locations.

Agricultural areas may support up to about 14 species of herps, nine of these being snakes. Fence rows, weed patches, and ungrazed pastures are the situations most likely to support lizards and snakes. Few situations are shady enough or sufficiently undisturbed to maintain populations of salamanders.

Grassland areas potentially contain nearly all species of lizards and snakes known from the study region. Toads or frogs may be present if moist conditions or freshwater ponds are available. Salamanders characteristic of woodland will be absent but a few generalists, including Ambystoma, spp., newts, and the slender salamander, may be found under the proper conditions of microhabitat.

Shrub habitats are quite similar to grassland in terms of herp species expected. Skinks may occur under these conditions of greater cover, but salamanders, frogs and toads are less frequent than in grassland unless the proper microhabitats are present around ponds or streams.

Closed-cone pine forest may be utilized by several species of snakes adapted to dry conditions and most lizard species. Salamanders, frogs and toads are not expected as a general rule.

Deciduous forest probably supports nearly as many herp species as are found in any habitat in the study area. Thirty-one species potentially occur, including representatives of all groups of amphibians and reptiles. The diversity of microhabitat situations created by the vegetational diversity of this habitat-type offers situations appropriate to each of these groups. High primary productivity of the area is the basis of insect productivity which in turn supports the relatively high numbers and diversity of species occurring in deciduous forest.

Evergreen forest potentially provides appropriate microhabitats for most salamander species and many of the local snake species, but is too cool, shaded and closed for most lizard species. Skinks are likely to occur and the treefrog and red-legged frog may appear in special circumstances.

Mixed deciduous and evergreen forest is nearly identical to deciduous forest with respect to herp species. Any differences actually detected could probably be attributed to microhabitat availability and certain specifics of habitat preferences by salamanders that are poorly understood at present.

Riparian forest areas may have the highest diversity of any habitat in the study area; 37 of the 44 species listed in Table E-6 (Appendix E) are potentially present here. Riparian habitat is structurally very diverse, extremely productive of insects, and, by definition, close to water. Only species that are quite specialized for drier conditions or more open habitats are absent from such areas.

Vegetated and sparsely vegetated dunes in the study area support at most a few species of herps. The gopher snake and rattlesnake may be brought there by the presence of small mammal prey. Lizards, such as the western fence lizard and the alligator lizard, are known to occur near beach and dune areas elsewhere but have not been recorded there in the study area.

Moving sand dunes are not expected to serve as habitat for any species of herp known from the study area.

Ditches, ponds and closed channels containing fresh water may be important habitats for treefrogs, true frogs, and turtles. Garter snakes may also occur in these aquatic habitats where they are expected to feed on small fish and invertebrates.

Rivers and creeks are utilized by aquatic species and their margins serve as prime habitat for many species of newts and salamanders.

Bay and open ocean waters are not expected to serve as habitat for any species of herp known from the study area.

Salt marsh and brackish marsh are habitats generally inaccessible to herp species because of the difficulty they have in maintaining water balance under such situations. One species, the Oregon garter snake, is reported to occur in brackish areas occasionally (Stebbins, 1966).

Fresh water marshes are prime habitat for aquatically oriented herp species. Frogs, turtles and snakes belonging to

eleven species are suspected to occur in such portions of the study area (Table 6, Appendix E).

Swamps are expected to contain the same species occurring in freshwater marsh with the exception of the Pacific gopher snake.

Mudflats are not known to be used by any herp species in the study area.

Jetties constructed in saline waters are not expected to be used by any herp species in the study area.

R. PRODUCTIVITY

Biological production is the accumulation of chemical energy by an organism. Primary production represents the amount of organic material produced by plants through photosynthesis. Primary productivity is the rate of primary production or the rate at which plants convert light energy and simple nutrient compounds to complex organic compounds. Thus, primary production is expressed in terms of plant material produced per unit area; whereas, primary productivity is expressed as plant material produced per unit area per unit time. In these discussions, rate of production and productivity may be used interchangeably.

Gross primary production represents total photosynthesis. It includes chemical energy used in respiration and accumulated chemical energy in the form of plant tissues (i.e. net primary production). Thus,

$$\text{GROSS PRIMARY PRODUCTION} = \text{NET PRIMARY PRODUCTION} + \text{RESPIRATION}$$

Net primary productivity is the rate at which plants store chemical energy in the form of organic material.

Plants form the base of food webs as the source of organic material and inorganic nutrients for primary consumers. Live plant materials are directly grazed by herbivores. Dead plant materials undergo decomposition to form the foundation of detritus-based food webs in soil sediments and aquatic habitats. Detritus in coastal estuaries is a primary source of organic material and nutrients for coastal food webs (Odum, 1961; Keefe, 1972; de la Cruz, 1973; Nixon and Oviatt, 1973; and Eilers, 1975).

Net primary production is measured in most productivity studies because it represents the amount of available food for consumers. However, net primary production values are more valuable when a time unit is designated. The rate or productivity describes the renewal of photosynthetic organic material over time and the availability of the material to consumer trophic levels.

The most widely used method for determining net primary productivity of macrophytes involves measuring the biomass that accumulates over the growing season. This entails the harvesting and weighing of plant material in a sample plot at a point in the growing season when biomass is at its seasonal peak. The results of this method are expressed as grams per square meter (g/m^2). The harvest method is best suited to vegetation such as annuals or herbaceous perennials where increments of seasonal growth are obvious. Since net productivity is the rate of production, it is most acceptable to sample periodically throughout the growing season. Thus, biomass can be monitored and the seasonal peak can be determined. Estimates of productivity based on seasonal peak starting crop often seriously underestimates annual rates of production (Gosselink, et

al., 1977). Various methods attempt to measure losses due to mortality, leaching, translocation to roots, and grazing. Also, underground material is often difficult to collect and is often estimated. Productivity values are highly influenced by the methodology used in these calculations (Gosselink, et al., 1977).

Primary productivity of microorganisms such as phytoplankton is often measured by the light and dark bottle technique. This method uses the oxygen content in water as a measure of photosynthetic production and respiratory consumption. Samples of phytoplankton populations are incubated in transparent and opaque bottles at a given depth or under simulated natural conditions for a time. Reduction in the oxygen concentration in the water of the opaque bottle provides an estimate of the respiration rate of the phytoplankton; the increase in oxygen in the transparent bottle indicates net photosynthetic activity. Results of this method are expressed in grams of oxygen (gO_2) produced during photosynthesis. This experimental method estimates the productivity of a natural system using a small sample; some inaccuracies may occur due to complications in sample collection and limitations of simulating natural conditions in a bottle (the "bottle effect"). Additionally, certain assumptions are required regarding the relationship between oxygen production to the production of organic material.

In another commonly used technique, the incorporation of a radiocarbon tracer (^{14}C) into the organic material of phytoplankton during photosynthesis is used to measure the rate of primary production. In this method, the total content of CO_2 of the experimental water is known and a definite amount of labelled carbon is added. After incubation, the content of ^{14}C in the phytoplankton is determined, which permits a calculation of the rate of carbon uptake expressed in grams of carbon (gC). The results are complicated by the movement of some of the radiocarbon back into the water due to respiration and as organic compounds. Consequently, the technique gives a measurement which lies between gross and net productivity (Whittaker, 1975).

In this review, primary productivity of Humboldt Bay habitat types is expressed as grams dry weight per square meter per year ($\text{g/m}^2/\text{yr}$) except for certain values given as gC. Results expressed as gC were converted to dry weight units by dividing gC by 0.45 (Westlake, 1963). Productivity values expressed as gO_2 were converted to gC by multiplying gO_2 by 0.278, and then converted to grams dry weight (Westlake, 1963). These conversion factors are based on several assumptions regarding the proportions of various organic compounds found in plant material. Also, the relationship between the evolution of oxygen and the accumulation of carbon during photosynthesis changes under different conditions. Therefore, the conversion factor relating gO_2 and gC is a general one which attempts to relate the productivity measurements of the two techniques. In some studies productivity values reported for various habitat types

are actually based on peak biomass during the growing season; it should be remembered that these values usually underestimate true net primary productivity.

Primary productivity has been measured by numerous authors in a variety of natural and cultivated communities throughout the world. The following table will aid in placing data presented in this profile in a worldwide perspective.

Table VI- 21

NET PRIMARY PRODUCTIVITY OF VARIOUS ECOSYSTEMS

<u>Ecosystem</u>	<u>Productivity (g/m²/yr)</u>	<u>Source</u>
Agricultural land		
annual crops	2,200	Westlake, 1963
perennial crops	3,000	Westlake, 1963
Desert scrub	70	Whittaker, 1970
Temperate grassland	500	Whittaker, 1970
Temperate deciduous forest	1,200	Westlake, 1963
Temperate coniferous forest	2,800	Westlake, 1963
<u>Spartina alterniflora</u>		
salt marsh, Georgia	2,362-3,990	Odum & Fanning, 1973
Phytoplankton		
(continental shelf)	350	Whittaker, 1970
Seaweed beds, Nova Scotia	358	Mann, 1973

Net primary productivity data for habitat types in Humboldt Bay are scarce. Harding (1973) estimated the net productivity of eelgrass (*Zostera marina*) based on peak biomass values during the growing season. He also reported net primary productivity of phytoplankton in Humboldt Bay. Rogers (1979) estimated net primary productivity of three vascular plants in a salt marsh habitat for three consecutive years. Net primary productivity data are lacking for other wetland and upland habitat types in Humboldt Bay.

Primary Productivity by Habitat Type

In the following discussion, primary productivity is discussed for each habitat type. Where no information is available for Humboldt Bay, data from similar plant communities at comparable latitudes is presented. In the discussion of productivities, the data will be related in terms of the following ranges: Low = 0-600 g/m²/yr; Medium = 600-1,200 g/m²/yr; High = 1,200-1,800 g/m²/yr; Very High = 1,800+ g/m²/yr. All data discussed are summarized in Table VI-24.

Urban-Industrial

Primary productivity in urban-industrial areas is usually low and of little value for wildlife. Vegetation is often sparse, exotic and managed for aesthetic rather than wildlife uses. In addition, no studies of urban primary productivity are known.

Agricultural

The rate of primary production in agricultural habitat types depends in part on large energy inputs, such as cultivation, irrigation, fertilization, genetic selection, and insect control. These energy inputs can be in the form of fossil fuel, animal work, or human work (Odum, 1971). A range of productivities under these various conditions is presented in Table VI-22.

Agriculture in the Humboldt Bay area is primarily live-stock grazing. Estimated hay production on one ranch in the Humboldt Bay region was 227 g/m² (Green, personal communication). This rough figure may underestimate the annual net productivity due to incomplete harvest of stubble and roots and losses from herbivorous consumption. Higher annual productivities can be obtained by repeated harvesting. Since agricultural productivity is principally used by man, only small amounts are available for export to aquatic systems or for wildlife.

Grasslands

Grasslands are non-forested upland areas dominated by grasses, herbs, and forbs. Temperate grassland productivity is listed by Whittaker (1970) as approximately 500 g/m²/yr. Most upland productivity estimates for grasses are lower than this value (Wiegert and Evans, 1964; Bernard, 1974; Bray, et al., 1959). Low values for grassland productivity are primarily a function of environmental factors of low soil moisture levels, particularly during summer months (Odum, 1971).

Shrubland

Shrubland habitat types are dominated by brush and shrubs in upland areas and riparian areas. In a Tennessee upland habitat net primary productivity was $572 \text{ g/m}^2/\text{yr}$ for a mixed shrub community (Whittaker, 1961). Whittaker (1966) also estimated primary productivity of different forest-shrub communities in Tennessee. This study reported a range of productivity figures for shrubs which increased with a decrease in the productivity of trees within the community (Table VI-22).

Productivity values are not available for riparian shrubland habitats. Higher primary productivity is expected for riparian habitats than upland habitats due to higher soil nutrient levels flushed from upland habitats and higher soil moisture levels (Aucclair, et al., 1976).

Woodland

Woodland habitat types in the Humboldt Bay region consist primarily of coniferous forest. In disturbed areas near urban centers, some deciduous forest and mixed deciduous/coniferous forest are also found. Deciduous forests are also found in riparian situations. A pine forest is confined mainly to the coastal dunes of North Spit.

Net primary productivity has been estimated for coniferous forest types on the East Coast and England (Ovington, 1956; Whittaker, 1966). Productivity figures are generally found in a range from medium to high (Table VI-22). A stand of giant fir (*Abies grandis*) in England yielded the greatest rate of production (Ovington, 1956).

In a review of coniferous forests in the Pacific Northwest, Waring and Franklin (1979) discuss the productivity of several forest types of the western slopes of the Cascade and Coast Ranges. They found huge accumulations of biomass which can be accounted for by the dominance of large, long-lived species. Young western hemlock-Sitka spruce forests on the Oregon coast (110 years) and 100 year old Douglas fir-western hemlock stands exhibited medium values for productivity (Fujimori, et al., 1976) (Table VI-22).

For old growth coastal redwood forests on the California coast, productivity figures are high (Westman, et al., 1975). Measurements in a young forest of coastal redwood suggests high productivities on good sites in its early growing stages (Fujimori, 1977). Whittaker (1966) described coastal redwood communities as "a special case of environmental favorableness in their combination of sustained soil moisture, low annual temperature amplitude, and periodic replenishment of nutrient supply by flooding and deposit of sediments."

Table VI-22

NET PRIMARY PRODUCTIVITY (g/m²/yr) OF VARIOUS PLANTS
FROM TERRESTRIAL HABITATS

<u>Species or Community</u>	<u>Productivity</u>	<u>Location (Source)</u>
AGRICULTURE:		
Cultivated crops without subsidies	5-200	Temperate climates (Odum 1971)
Cultivated crops with subsidies	200-2,000	Temperate climates (Odum 1971)
Annual crops	2,200	Temperate climates (Westlake 1963)
Perennial crops	3,000	Temperate climates (Westlake 1963)
GRASSLAND		
<i>Poa compressa</i>	200	Michigan (Wiegert and Evans 1964)
<i>Poa pratensis</i>	176	Minnesota (Bernard 1974)
<i>Aristida purpurascens</i>	100	Michigan (Wiegert and Evans 1964)
<i>Aristida basiramea</i>	110*	Minnesota (Bray, et al. 1959)
<i>Setaria glauca</i>	80*	Minnesota (Bray, et al. 1959)
<i>Sorghastrum nutans</i>	150*	Minnesota (Bray, et al. 1959)
<i>Secale cereale</i>	380*	Minnesota (Bray, et al. 1959)
Temperate grasslands	500	Temperate climates (Whittaker 1970)
SHRUBLAND:		
Mixed shrub	572	Tennessee (Whittaker 1961)
Mixed shrub	953	Tennessee (Whittaker 1966)
Mixed shrub/forest	160-320	Tennessee (Whittaker 1966)
<i>Rhododendron maximum</i>	176	Tennessee (Whittaker 1966)
WOODLAND		
Spruce forests	920-980	Tennessee (Whittaker 1966)
<i>Picea abies</i>	725-1,125	England (Ovington 1956)
<i>Tsuga heterophylla</i> - <i>Picea sitchensis</i>	935	Oregon (Fujimori, et al. 1976)
<i>Pseudotsuga menziesii</i> - <i>Tsuga heterophylla</i>	1,153	Oregon (Fujimori, et al. 1976)
<i>Tsuga heterophylla</i>	1,294	England (Ovington, 1956)
<i>Abies grandis</i>	1,840	England (Ovington, 1956)
Coastal Redwood	1,270-1,440	California (Westman, et al. 1975)
Mixed deciduous	1,050-1,150	Tennessee (Whittaker 1966)
<i>Quercus alba</i>	1,200	Tennessee (Whittaker 1966)
Mixed oak-pine forest	800	New York (Whittaker & Woodwell 1969)
Pine forests	820-950	Tennessee (Whittaker 1966)
<i>Pinus sylvestris</i>	1,270	England (Ovington 1957)
<i>Pinus muricata</i>	1,090	Mendocino County, CA (Westman et al. 1975)

*represents peak biomass

Information on West Coast deciduous forests is lacking and data presented here comes from the work of Whittaker (1966) and Whittaker and Woodwell (1969) on mixed deciduous East Coast forests (Table VI-21). Net primary productivities in the medium range were reported in the oak-pine and oak forests of New York and Tennessee, respectively. The lower productivity of the oak-pine forest compared to the deciduous forests in Tennessee was attributed to low soil nutrient levels combined with frequent exposure to fire at the oak-pine forest on Long Island.

Westman, et al., (1975) described a Pinus muricata (bishop pine) forest growing on coast terrace foredunes in Mendocino County, California. The stature of this forest, which ranges from 15-30 meters in height and has a well-developed shrub layer, is similar to the pine forest of North Spit of Humboldt Bay. A mean of the calculated productivities was $1,090 \text{ g/m}^2/\text{yr}$ with a range of $273\text{-}1,609 \text{ g/m}^2/\text{yr}$. The range represents a gradient in nutrient conditions (Westman, et al., 1975).

Water Habitats

Water habitat types in the study area include the deep channels, tidal channels, tidal creeks, sloughs, and cutoff channels in Humboldt Bay, as well as rivers and creeks that flow into Humboldt Bay.

Phytoplankton are the main primary producers in deep channels and the water column above mudflats at high tide. Using radio carbon productivity techniques, Harding (1973) calculated net primary production values for the growing season (136 days) at 312.8 g/m^2 and 448.8 g/m^2 for high and low water, respectively (Table VI-22). (Phytoplankton production is concentrated into a smaller area at low tide, resulting in a higher production per unit area.)

Nixon and Oviatt (1973) reported that net productivity of phytoplankton in a Rhode Island embayment was $111.2 \text{ g/m}^2/\text{yr}$ ($180 \text{ gO}_2/\text{m}^2/\text{yr}$). Westlake (1963) reported (from Riley, 1956) that net productivity of phytoplankton in Long Island Sound was $380 \text{ g/m}^2/\text{yr}$. (See Table VI-22.)

Although net productivity of Humboldt Bay phytoplankton is not high, the large area occupied by phytoplankton in deep channels, tidal channels, and shallow bays makes them an important contributor to Humboldt Bay food webs.

Tidal creeks and sloughs are characterized by low to high net primary productivity values in areas with saline influence from tidal activity and freshwater influence from rivers and creeks. In a Rhode Island embayment peak biomass, values of widgeon grass ranged from 180 g/m^2 in areas of relatively low plant densities to $1,460 \text{ g/m}^2$ in areas of relatively high plant densities.

The net primary productivity of cutoff channel habitat types is discussed under the section of non-tidal freshwater marsh habitat, which supports a similar flora, since cutoff channels are no longer under tidal influence.

In his review of river and stream habitats from various temperate regions, Westlake (1963) reported low net primary productivities. The collective productivities of phytoplankton, vascular plants, and benthic algae ranged from 100-600 g/m²/yr (Table VI-23). These productivity values are low compared to productivity of other habitat types, particularly since other habitats were considered by respective component plant types (e.g., phytoplankton in deep channels and tidal channels). Since stream primary productivity is low, the large array of consumers in rivers and streams depends on organic materials that fall in from terrestrial vegetation. Thus, rivers and creeks are important as transporting agents of plant material (i.e., net primary productivity) produced in other habitats (Odum, 1971).

Salt Marsh

The vegetation of Humboldt Bay salt marshes is dominated by two vascular plants: cordgrass (Spartina foliosa) and pickleweed (Salicornia virginica). Saltgrass (Distichlis spicata) frequently co-dominates at higher salt marsh elevations with pickleweed. Rogers (1979) reported productivity values for these three plants in Humboldt Bay. Net primary productivity values were higher during growing seasons in 1976 and 1978 following periods of average rainfall; productivity declined in 1977 under drought conditions from 1976 through the 1977 growing season. The productivity values of cordgrass and saltgrass reflected true net primary productivity. For comparison, it should be noted that much higher values for saltgrass and cordgrass (S. patens) has been reported in Gulf Coast marshes (Gosselink, et al., 1977). Net productivity of pickleweed was based on peak biomass. This method of estimating productivity probably represented true net productivity for pickleweed because of its well-defined growing season and low mortality during the growing season (Rogers, 1979).

Mahall and Park (1976) estimated net primary productivity of pickleweed and cordgrass using peak biomass of live plant material in San Francisco Bay (Table VI-23).

Pomeroy (1959) reported that the productivity of algae (green algae, blue-green algae, and diatoms) in Georgia salt marshes and adjacent mudflats was a significant contribution to the energy flow of an estuary ecosystem. Net algae productivity was highest during winter months (66 g/m²/month) when the shading effect of cordgrass is reduced. Annual net algae production in the Spartina alterniflora salt marsh was low (316 g/m²/yr) (Pomeroy, 1959).

The importance of algal productivity in Humboldt Bay salt marshes may not be that significant during late spring, summer, and early fall because of the shading effect in dense stands of pickleweed and cordgrass. As in Georgia salt marshes, algal productivity in stands of pickleweed may be more important during late fall, winter, and early spring when the thin, dormant woody stems of pickleweed allow more light to reach the salt marsh surface. The large biomass of cordgrass, even during winter, probably precludes high algal productivity in Humboldt Bay (Rogers, 1979).

Although total acreage of salt marshes is low compared to other Humboldt Bay habitat types, the high net productivity of cordgrass makes salt marshes an important contributor of organic matter to Humboldt Bay food webs (Rogers, 1979). Salt marshes are normally inundated twice a day by high tides; it is this high interaction with the aquatic system which results in the export of plant production to the bay.

Brackish Marshes

Brackish marshes are common adjacent to tidal creeks, where tidal influence tends to raise salinity and freshwater runoff depresses salinity. Important contributors to primary production of brackish marshes near Humboldt Bay are rushes (Juncus spp.), hairgrass (Deschampsia caespitosa), sedges (Carex spp.), bulrushes (Scirpus spp.), and silverweed (Potentilla sp.). Many of the dominant brackish marsh genera may also be common in freshwater marshes (i.e. rushes, sedges, and bulrushes). Primary productivity of each plant was treated separately in the following sections on brackish marshes and freshwater marshes, and are summarized in Table VI-23.

Net primary productivities and peak biomass values for the brackish marsh plants found in Humboldt Bay were reported from a similar marsh at Nehalem Bay, Oregon (Eilers, 1975). Tall and short growth forms of sedges were a major contributor of primary production. The calculated mean net productivity was high for the tall Carex lyngbyei. The net productivity values for short Carex lyngbyei were half that of the tall form. High productivity values are also reported for Juncus balticus in the Nehalem brackish marsh. Only medium productivity was reported for Scirpus maritimus (Table VI-23).

In a mixed community dominated by hairgrass, peak biomass values indicate a lesser contribution than sedges and rushes to the total primary production of brackish marshes in Nehalem Bay. In areas of heaviest dominance of hairgrass, mean peak biomass of hairgrass was low; however, exceptional growth ($1,278 \text{ g/m}^2$) was reported at one site (Eilers, 1975). Silverweed (Potentilla pacifica) was also measured in the Nehalem brackish marsh with a low value for peak biomass.

Freshwater Marshes

Freshwater marshes are common in the diked flatlands of Humboldt Bay. The presence of cattails (Typha sp.) characterizes freshwater marshes, although rushes, sedges, and bulrushes are also found.

Peak biomass values for most freshwater marsh plants vary within a range from 600 to 1,500 g/m², with the highest values reported for cattails (Typha spp.) (Table VI-23). Jervis (1969) calculated very high net primary productivity for a Typha angustifolia and Typha latifolia community in New Jersey. One medium value for peak biomass of cattails in South Carolina was attributed to low soil fertility (Boyd, 1970).

Rushes, sedges, and bulrushes exhibit medium peak biomass values in the freshwater marsh (Pearsall and Gorman, 1956; Jervis, 1969; Bernard, 1974; Auclair, et al., 1976). Bulrushes sampled in Quebec, Canada, were found to accumulate a peak biomass of 930 g/m². In several other temperate region sites, low values have been reported. These low values were attributed to low soil fertility for a marsh in South Carolina (Boyd, 1970) and low dominance value for bulrush in a mixed marsh in New Jersey (Jervis, 1969). Rushes and sedges tend to show medium peak biomass values over a range from 420 to 800 g/m².

Since freshwater marshes are non-tidal, aquatic interaction is usually low, and much of the organic material produced is unavailable to the aquatic ecosystems. Interaction with streams and rivers may occur in some freshwater marshes, especially during periods of high rainfall. This interaction occurs seasonally or intermittently in most instances. In marshes isolated from rivers or streams, interactions with units of the aquatic ecosystem are insignificant.

Swamps

Swamps are characterized by willows (Salix spp.), twinberry (Lonicera involucrata), Spiraea (Spiraea douglasii), alder (Alnus rubra), and spruce (Picea sitchensis). Spiraea and willow are more prevalent in tidally influenced swamps.

Eilers (1975) estimated very high net productivity for a tidal spruce-willow swamp in Nehalem Bay. Jervis (1969) determined peak biomass values for different plants that comprise a "sedge-shrub community" at Troy Meadows, New Jersey. The main primary producers of this community were sedges (Carex spp.) (583 g/m²) and arum (Peltandra sp.) (231 g/m²), both of which are plants of the understory. Button bush (Cephalanthus occidentalis), willow and Spiraea taken together contributed 287 g/m². Total community primary production (based on peak biomass of the component species) was estimated to be 1,699 g/m² (Jervis, 1969).

Table VI-23

PEAK BIOMASS (g/m²) AND NET PRIMARY PRODUCTIVITY (g/m²/yr) OF
VARIOUS PLANTS IN AQUATIC AND TIDAL HABITAT TYPES

<u>HABITAT/Species</u>	<u>Peak Biomass</u>	<u>Produc- tivity</u>	<u>Location (Source)</u>
SALT MARSH:			
<i>Spartina patens</i>	--	4,159	Louisiana (Gosselink, et al. 1977)
<i>S. foliosa</i>	854	2,525	Humboldt Bay (Rogers 1979)
<i>S. foliosa</i>	689	--	San Francisco Bay (Mahall and Park 1976)
<i>S. foliosa</i> (drought)	248	798	Humboldt Bay (Rogers 1979)
<i>Salicornia virginica</i>	764	764	Humboldt Bay (Rogers 1979)
<i>S. virginica</i>	950	--	San Francisco Bay (Mahall and Park 1976)
<i>S. virginica</i> (drought)	425	425	Humboldt Bay (Rogers 1979)
<i>Distichlis spicata</i>	--	2,881	Louisiana (Gosselink, et al. 1977)
<i>D. spicata</i>	260	347	Humboldt Bay (Rogers 1979)
<i>D. spicata</i>	196	198	Humboldt Bay (Rogers 1979)
algae	--	316	Georgia (Pomeroy 1959)
MUDFLATS:			
algae	--	400	Georgia (Pomeroy 1959)
<i>Zostera marina</i>	300-800	--	Humboldt Bay (Harding 1973)
WATER:			
phytoplankton	--	313-449	Humboldt Bay (Harding 1973)
phytoplankton	--	380	Long Island Sound (Westlake 1963)
<i>Ruppia</i>	180-1,460	--	Rhode Island (Nixon and Oviatt 1973)
BRACKISH MARSHES:			
short <i>Carex lyngbyei</i>	248-953	875	Oregon (Eilers 1975)
tall <i>Carex lyngbyei</i>	1,279-2,629	1,746	Oregon (Eilers 1975)
<i>Juncus balticus</i>	920	1,358	Oregon (Eilers 1975)
<i>Scirpus maritimus</i>	309	609	Oregon (Eilers 1975)
<i>Deschampsia caespitosa</i>	1,287	--	Oregon (Eilers 1975)
<i>Potentilla pacifica</i>	579	--	Oregon (Eilers 1975)
FRESHWATER MARSHES:			
<i>Carex rostrata</i>	420	--	England (Pearsall & Gorham 1956)
<i>Carex rostrata</i>	738	--	Minnesota (Bernard 1974)
<i>Carex acutiformis</i>	630	--	England (Pearsall & Gorham 1956)
<i>Carex stricta</i>	703	--	New Jersey (Jervis 1969)
<i>Juncus effusus</i>	800	--	England (Pearsall & Gorham 1956)
<i>Juncus squarrosus</i>	690	--	England (Pearsall & Gorham 1956)
<i>Scirpus americanus</i>	150	--	South Carolina (Boyd 1970)
<i>Scirpus fluviatilis</i>	930	--	Quebec (Auclair, et al. 1976)
<i>Deschampsia caespitosa</i>	1,010	--	England (Pearsall & Gorham 1956)
<i>Typha latifolia</i>	684	--	South Carolina (Boyd 1970)
<i>Typha latifolia</i>	1,070	--	England (Pearsall & Gorham 1956)

Table VI-23 (Continued)

<u>HABITAT/Species</u>	<u>Peak Biomass</u>	<u>Produc- tivity</u>	<u>Location (Source)</u>
FRESHWATER MARSHES (Continued):			
<i>Typha latifolia</i> + <i>Typha angustifolia</i>	1,566	1,905	New Jersey (Jervis 1969)
<i>Typha latifolia</i> - <i>angustifolia</i>	1,360	--	Minnesota (Bray, et al., 1959)
JETTIES AND REEFS:			
<i>Fucus</i> + <i>Ascophyllum</i>	--	1,422-1,867	Nova Scotia (Mann 1973)
Laminarians	--	4,000	Nova Scotia (Mann 1973)

A large portion of organic production from the non-tidal swamps of Humboldt Bay is retained in the swamp, as evidenced by peat accumulations or a rich organic soil horizon. Aquatic interaction is low and probably limited to floods or periods of high rainfall. When swamps are close to rivers or streams, leaf fall into the moving water can become an important source of plant material exported downstream.

Mudflats

Mudflats comprise the largest habitat type in Humboldt Bay. "Bare" intertidal mudflats occur above mean lower low water (MLLW), while extensive eelgrass (Zostera marina) beds occupy much of intertidal mudflats below MLLW and some subtidal mudflats. Subtidal mudflats are found in areas of Humboldt Bay that are not exposed even during the lowest low tide of the year.

Nixon and Oviatt (1973) reported that inconspicuous green algae, blue-green algae, and diatoms in "bare" intertidal mudflat sediments contributed 30-40% of the total primary production of an embayment in Rhode Island. At peak biomass the green algae Ulva lactuca and Enteromorpha spp. reached 260-600 g/m².

Pomeroy (1959) reported two peak levels of gross primary productivity of mudflat algae. During winter, gross algal productivity averaged 54.9 g/m²/month (24.7 gC/m²/month). Gross algal productivity during summer averaged 81.1 g/m²/month (36.5 gC/m²/month). Lower levels of productivity were reported during spring and fall. Gross algal productivity was estimated to be 444 g/m²/yr (200 gC/m²/yr). Net primary productivity was estimated to be 90% of gross primary productivity; thus, net algal productivity was 400 g/m²/yr (180 gC/m²/yr).

Eelgrass productivity for Humboldt Bay was estimated from peak biomass values (Harding, 1973; Harding, et al., 1975). South Bay, which contains 78-91% of the eelgrass (by dry weight) in Humboldt Bay, supports the densest stands of eelgrass. Peak biomass of 800 g/m² is reported in areas of heavy eelgrass growth and 600 g/m² in areas of medium growth. Arcata Bay produced 300 g/m² in areas of medium to light growth. These estimates represent a minimum value for net production since losses attributable to herbivore grazing and physical removal of broken young shoots were not considered.

Dunes

Sand dunes are sparsely vegetated areas of migrating sand. Productivity of sand dune vegetation is very low because nutrients and water are limiting in the unstable sand environment (Ranwell, 1972; Chapman, 1976).

Data on primary productivity of sand dune habitats are lacking. In a laboratory experiment, Johnson (1963) determined relative

dune productivities by growing plants in sand collected from five different sand dune microhabitats (e.g., foredunes). Plants grown in sand from moving-dunes (0.4 grams dry wt per plant) were the least productive followed in order of increasing soil productivity by foredunes (0.5 grams dry wt per plant), stabilized ridges (0.8 grams dry wt per plant), hollows under Carex spp. (0.8 grams dry wt per plant), and dune forest under Abies (fir), Pinus (pine), and Picea (spruce) (1.1 grams dry wt per plant) (Johnson, 1963).

Jetties and Reefs

Jetties and reefs are relatively small areas near the mouth of Humboldt Bay. Red and brown algae of various species cover much of the intertidal and subtidal substrate. Primary productivity of subtidal seaweeds was very high in Nova Scotia. Perennial laminarians accounted for close to 4,000 g/m²/yr (1,750 gC/m²/yr) (Mann, 1973). Productivity of intertidal seaweeds was lower than subtidal. The range of net primary productivity of intertidal algae (mainly Fucus and Ascophyllum) was 1,422 to 1,867 g/m²/yr (640-840 gC/m²/yr) (Mann, 1973). The critical factors contributing to the high primary productivity of seaweeds were active year-long growth and wave action keeping the blades in constant motion, providing maximum exposure to sunlight and contact with suspended and dissolved nutrients (Mann, 1973).

Summary

Net primary productivity of terrestrial communities varies from low in certain agricultural and grassland habitats to high in some woodland and certain agricultural habitats (Table VI-24). Low productivity in terrestrial habitats is attributed to low soil moisture levels and highly variable soil nutrients (Odum, 1971). Net production in coniferous and deciduous forests decreased from areas with high soil moisture to areas with low soil moisture (Whittaker, 1966). Whittaker (1966) also determined that there was no significant difference in net production of deciduous forests and coniferous forests. Forests on the coast of northern California are often referred to as "temperate rain forests" (Odum, 1971). Although net primary productivities of some terrestrial habitats are low, flushing of nutrients from these upland habitats to highly productive aquatic and wetland habitats makes most terrestrial habitats important contributors to food webs within the Bay system.

Aquatic wetland habitat types in Humboldt Bay are highly productive (Table VI-24). The most productive habitat types are relatively small areas of very high primary productivity (i.e. salt marshes, brackish marshes, freshwater marshes, and jetties) or relatively large areas of moderate to high primary productivity (i.e. eelgrass flats, mudflats, and open water in shallow bays and channels).

Table VI- 24

ESTIMATED RANGE OF NET PRIMARY PRODUCTIVITY
FOR HABITAT TYPES IN HUMBOLDT BAY

<u>Habitat Type</u>	<u>Productivity</u>	<u>Remarks</u>
Agriculture	200-500*	Based on peak biomass of hay crop in Humboldt Bay area. Higher figures may occur under repeated harvesting or for cultivated crops.
Grasslands	100-500	Peak biomass values from similar temperate climates (Bray, et al., 1959; Whittaker, 1970).
Shrubs	400-900	Tennessee mixed shrubland (Whittaker, 1961; Whittaker, 1966).
Forests:		
Coniferous	900-1,300	From numerous sources along West Coast for old growth stands. Young stands exhibit higher productivity.
Deciduous	800-1,200	East Coast deciduous forests (Whittaker, 1966; Whittaker and Woodwell, 1969).
Pine	500-1,200	Variability related to soil fertility. From Mendocino County bishop pine forest (Westman, et al., 1975).
Water:		
Tidal channels	300-450	Phytoplankton productivity in Humboldt Bay (Harding, 1973).
Rivers, streams	100-600	Temperate sites (Westlake, 1963)
Salt Marsh:		
Cordgrass	2,500	Humboldt Bay (Rogers, 1979)
Pickleweed-saltgrass	1,000-1,300	Humboldt Bay (Rogers, 1979)
Brackish Marsh	900-1,700	Nehalem Bay (Eilers, 1975)
Freshwater Marsh	700*-1,900	Cattail marsh with highest productivity, sedges and rush less significant (Jervis, 1969; Auclair, et al., 1976)
Swamps	1,700-1,900	Nehalem Bay (Eilers, 1975) and New Jersey (Jervis, 1969).

Table VI-24 (Continued)

<u>Habitat Type</u>	<u>Productivity</u>	<u>Remarks</u>
Dunes	very low- moderate	Gradient in productivity of sparsely vegetated dunes, forested dunes and dune swamps.
Jetties and Reefs	1,400-1,900	Based on intertidal algae in Nova Scotia (Mann, 1973).
Eelgrass	300-800*	Humboldt Bay. Probably underestimated true net productivity (Harding, 1973).
Mudflats	400	Mudflat algae in Georgia (Pomeroy, 1959)

*Based on peak biomass data.

The high productivity in aquatic and wetland habitats is a result of a number of factors. Nutrient-rich estuarine waters are important in maintaining high productivity of phytoplankton, seaweeds, and mud algae (Pomeroy, 1959; Odum, 1961; Keefe, 1972). Tidal flushing of this nutrient-rich water over intertidal areas helps in maintaining high sediment nutrient levels in mudflats (including eelgrass flats), salt marshes, and brackish marshes (Keefe, 1972). High nutrient levels are maintained in freshwater marshes by flushing of nutrients from surrounding uplands (Auclair, et al., 1976). High soil moisture in freshwater, brackish, and salt marshes holds nutrients in a dissolved state making them readily available for vascular plants.

Leaf orientation is important in maintaining high rates of photosynthesis. Wave activity keeps the blades of seaweeds in constant motion, providing maximum exposure to sunlight (Mann, 1973). The vertical orientation of vascular plants in freshwater, salt, and brackish marshes aids in maintaining a high photosynthetic rate by reducing intense heating, exposing the maximum leaf surface to sunlight over the day, and minimizing mutual shading (Jervis, 1969; Keefe, 1972; Auclair, et al., 1976).

S. FOOD WEBS

Food webs are an ecological concept used to describe the movement of energy and nutrients through an ecosystem. An understanding of food webs is a prerequisite to comprehending the complexities of ecosystem function. The primary components of food webs are chemical energy, nutrients, and organisms occupying different trophic levels. The first part of this discussion defines these components and identifies their significance.

An ecosystem encompasses a community of organisms and the biotic and abiotic factors in the surrounding physical environment. It may be as small as a fish bowl or as large as an ocean. Generally, the larger an ecosystem, the more complex are its food webs. To simplify the description of the estuarine ecosystem, the second portion of this discussion identifies food webs within each habitat type of the estuary. The summary combines the habitat types into a single description of the Humboldt Bay food web.

Energy and Nutrients

Energy and nutrients, in the form of inorganic ions or organic compounds, are the commodities that move through the ecosystem along pathways of the food web. Every organism in the estuary requires the continuous procurement of these components.

Energy enters the ecosystem as both light and heat. Although visible light and heat differ only in wave length, their uses in the ecosystem are quite different. Through plant photosynthesis, the energy in sunlight is converted to chemical energy and stored as sugars and other organic compounds. This is generally considered to be the most important energy transformation that occurs in an ecosystem. The entire food web is limited by the amount of light energy that is converted to chemical energy and stored by plants, the primary producers.

Energy entering the system as heat is absorbed by water, soil, and organisms. Heat, stored as thermal energy, creates a suitable environment in which organisms can function. For every organism there is an optimum functioning temperature. If the amount of available heat is such that the ambient temperature differs significantly from this optimum temperature, the organism does not function at its greatest efficiency. Thus, heat, although not used directly by organisms within an ecosystem, is an important factor that regulates the efficiency of those organisms, particularly the cold-blooded animals.

There are several major and minor elements which are considered to be nutrients within an ecosystem. More technically, they are usually chemical elements or minerals that are continuously re-

cycled in an ecosystem. The major nutrients are carbon, nitrogen, and phosphorus. Water and oxygen are also vital for maintenance of normal physiologic functions. Other important elements include sulfur, calcium, sodium, potassium, magnesium, zinc, iron, and other trace metals. These elements are incorporated in complex molecules that provide the structural and functional units utilized by all organisms in an ecosystem.

These elements move through a food web along the same pathways as energy; i.e., they are incorporated in chemical compounds. Unlike energy, however, they are not eventually dissipated as heat, but instead are recycled through the ecosystem by both organic and inorganic processes. (An expanded discussion of nutrient cycling is found in the following section.)

Trophic Levels

The transfer of energy and nutrients can best be characterized in terms of trophic levels. A trophic level is a major energy transportation step in a food web. The number of trophic levels represents the number of times energy has been transformed after entering the system. Normally, chemical energy cannot be transformed more than 3-5 times before it is converted totally to heat and lost to the ecosystem.

As mentioned previously, energy enters the ecosystem as sunlight, is transformed by plants into chemical energy, and is then stored as sugars and other complex organic molecules. The energy and elements contained in these molecules are then either recombined to form complex compounds within the plant, or they are returned to the ecosystem through various metabolic processes. Thus, primary production, consisting of light energy conversion to chemical energy and the subsequent synthesis of proteins, carbohydrates, and other chemical constituents of plant material, is the function of the first trophic level.

The second trophic level consists of primary consumers, those organisms that feed on the products of primary production. There are two different types of primary consumers: grazers or herbivores, which feed on living plant material, and detritivores, which feed on dead plant material. These two types of primary consumers form two distinct food webs and provide foundations for the second transfer of energy within the ecosystem. Thus, in the following discussion, references will be made to either grazing (or browsing) food webs and detritus food webs.

The remaining trophic levels are comprised exclusively of carnivores (animals that consume other animals). First order carnivores (third trophic level) feed on detritivores and/or herbivores of the second trophic level. These carnivores may, in turn, be con-

sumed by second order carnivores. In general, three levels of carnivores are recognized, although this is not an absolute limitation. For instance, the complex food webs of the ocean may include three levels of planktonic carnivores, as well as a top carnivore that feeds directly on the primary consumer (as is the case with whales and euphasiid shrimp). In most ecosystems, however, 1-3 levels of carnivores, and a total of 3-5 trophic levels, are sufficient to describe the food web.

A final, and critical component of food webs are the decomposers. Decomposers consist of bacteria, fungi, and other organisms that consume dead organic material, or excrement, and convert it to metabolic energy and inorganic nutrients. Decomposers feed on dead, decaying material contributed from all trophic levels and, therefore, do not represent a specific trophic level. Decomposition is the primary process by which nutrients are made available for recycling.

Decomposition is an extremely important process which results in detritus, a major connecting link between wetlands and the estuarine ecosystem. Detritus consists of small particles of organic matter, such as vegetation, being consumed by bacteria or fungi. These microorganisms are rich in protein and other organic compounds; their presence considerably enhances the food value of the particulate matter. This nutrient-enhanced particulate material is an important energy source to the numerous detritus feeders found in the estuary.

An important aspect of energy flow through an ecosystem is the efficiency with which energy moves from one trophic level to the next. Three steps are noted in the process of energy flow between trophic level: ingestion, assimilation, and consumer production. For each of these steps an efficiency of energy transfer can be defined and calculated. The efficiency of energy transfer at any trophic level is a product of the efficiencies of each of these three steps.

Exploitation efficiency, the ratio of prey consumed to prey produced, is difficult to measure, but has been estimated from trophic energy flow studies. For herbivores it varies from 1 to 10 percent; for carnivores it may vary from 10 to 100 percent depending on season, predator, prey species, and other variables (Ricklefs, 1973).

Gross production efficiency, the ratio of consumer production to ingestion, has been determined for a wide variety of species. In aquatic organisms it may vary from 1.5% in the stream limpet (Ferissia rivularis) to 32% in Megalops cyprinoides, a freshwater fish (Ricklefs, 1973). In insects it may vary from 5 to 15%, in mammals from 0.5 to 4.5% (Ricklefs, 1973).

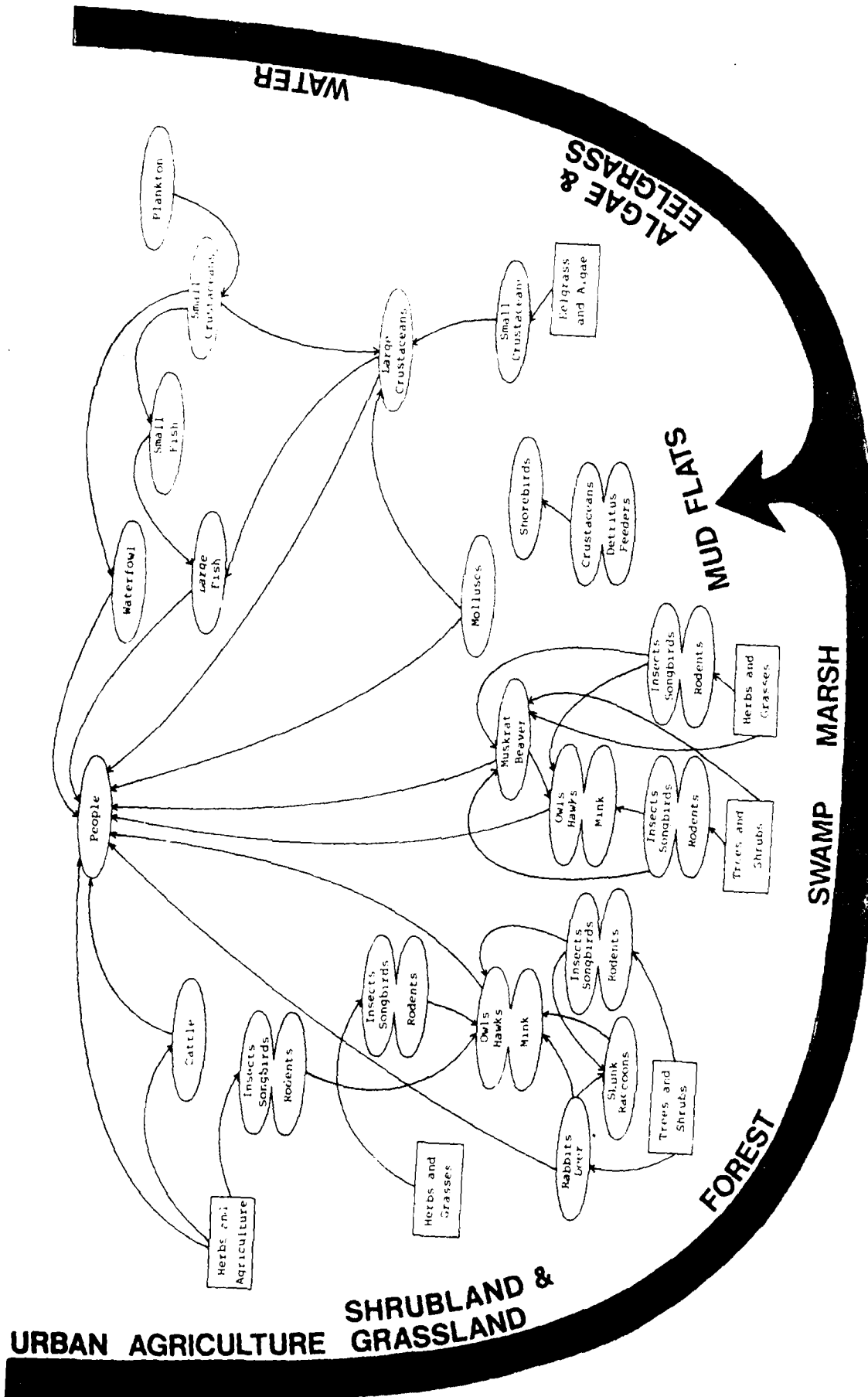
It should be noted that many organisms may occupy more than one trophic level. Carnivores, in particular, might feed on other carnivores, herbivores, or occasionally plants. Some plants, which are normally defined strictly as primary producers, might also occupy other trophic levels. For example, parasitic plants and carnivorous plants are in second and third trophic levels respectively.

Community Food Webs by Habitat Type

With a basic understanding of trophic levels, it is possible to describe food webs of the various habitat types found in the Humboldt Bay estuary. The following contains a generalized description of representatives of each trophic level found in different habitats. The species mentioned may not necessarily be found in every example of a habitat type, but are present with sufficient regularity to justify their inclusion in this discussion. Due to their similarity in various habitat types, decomposers will not be considered specifically in this discussion. Following this description will be a discussion of the entire estuarine ecosystem and the relationship of the various habitat types to that ecosystem. Figure VI-37 is a graphic illustration of a food web for the estuary ecosystem. Figure VI-38 represents in detail a single habitat type within the estuary.

The urban habitat type represents a highly altered and often artificial ecosystem. Nutrients are added as fertilizers, with excess quantities eventually leaching into the local runoff. Most of the primary consumption has been eliminated. Trees, shrubs, and annuals which do exist are often protected from consumption by fences and insecticides. Insects and rodents are the common primary consumers; songbirds are the prevalent first order carnivores that prey on the insects. Domestic animals (e.g., cats) prey on the rodents. Decomposers may be found in lawns or gardens, but much of the dead and excretory material is carried to sanitary landfills or other locations.

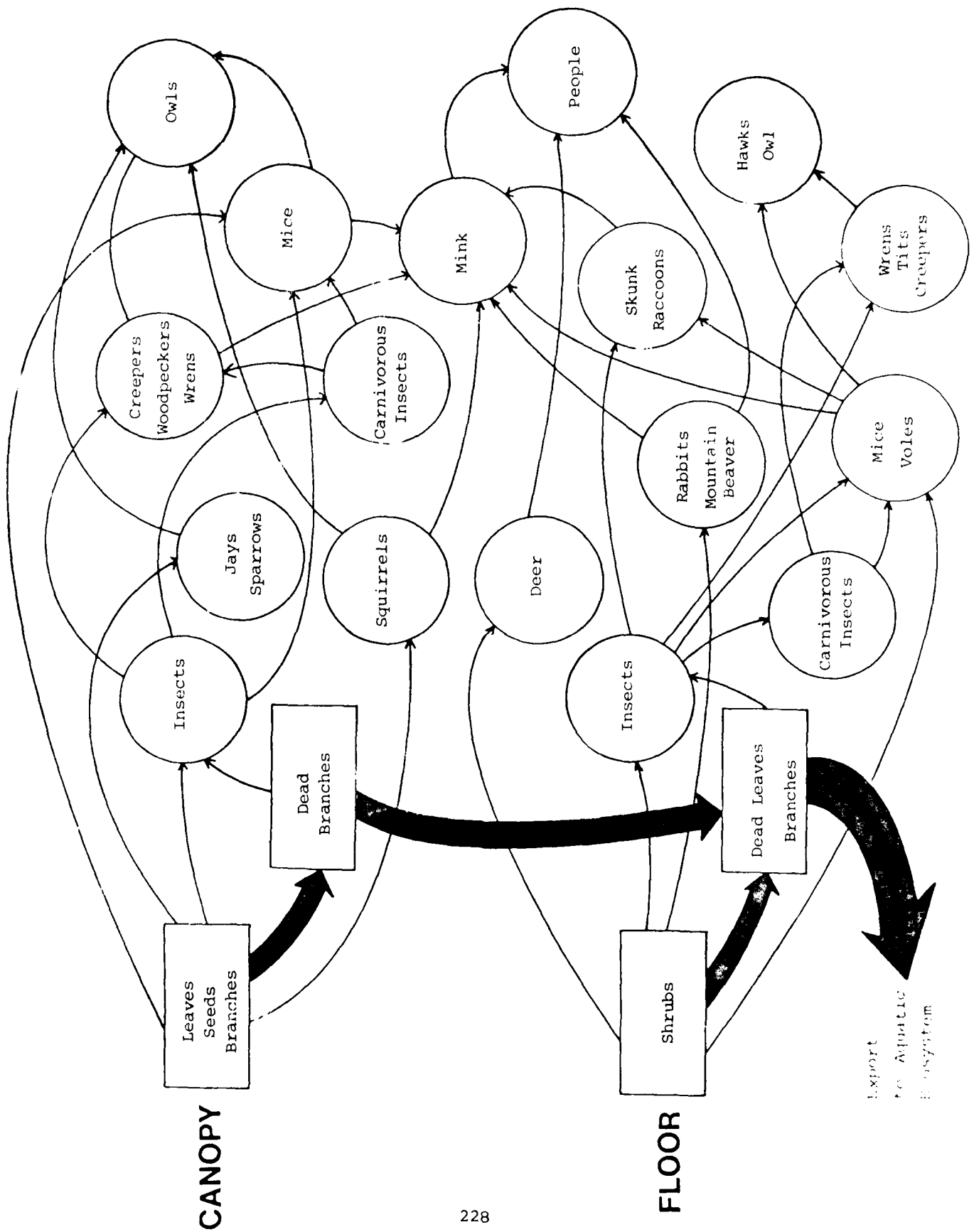
Agricultural lands are also highly altered ecosystems. These are areas of primary production that support the human populations of urban areas. In addition to the products harvested by man, a small secondary food web is based on agricultural primary production. Rodents, such as mice and gophers, commonly inhabit crop lands and pastures, feeding on seeds and vegetation. Insects and small birds, such as sparrows, are important primary consumers in agricultural areas. With the exception of spiders or omnivorous rodents, there are few carnivores that live in the agriculture habitat type. Swallows and other insect-eating birds often enter the fields as first order carnivores. Mink, raccoon, and raptors (hawks, eagles, and owls) may also enter, preying on rodents or small birds. A portion of the agricultural production is exported to the aquatic habitat as detritus. In addition, varying amounts of organic nutrients from fertilizers may be transported to the estuary.



FOOD WEB FOR ESTUARY ECOSYSTEM

Figure VI-37

FOREST SWAMP HABITAT



The grassland habitat type supports a more varied and complex food web than those mentioned previously. A mixed population of grasses and herbs is the source of primary production. Mice, voles, gophers, sparrows, and insects are all important primary consumers along with deer and pheasants that may enter the grassland to feed. Resident first order carnivores include shrews, night hawks, and short-eared owls. Swallows are insectivores, and commonly visit grassland areas to feed. Minks, raccoons, and raptors all may prey on the small birds and mammals that inhabit grasslands. A small amount of grassland detritus and nutrients are exported to the estuary.

In the shrubland habitat type, primary production occurs in both woody and leafy plants. Woody material provides a food source for certain worms, insects and birds, while leafy vegetation and seeds are consumed by deer, rabbits, mice, insects, and songbirds. Resident first order carnivores include shrews, wrens, and creepers. Other carnivores found in the shrub habitat include snakes, skunks, minks, and raccoons. Dead leaves and branches may decompose in the area or a portion of the resulting nutrients may be exported to the estuarine habitat.

In the forested habitat type, trees and shrubs are the primary producers and form the basis for several different food webs. In the canopy there is a browsing food web based on leafy primary production and a detritus food web based on dead branches and tree trunks. On the forest floor, there is also both a browsing and a detritus food web. The former is based on young trees, shrubs and herbs, and the latter, on leaf litter.

Primary consumers of the forest canopy browsing web include insects, squirrels, tree mice, jays, sparrows, and other seed-eating birds. Insectivorous birds such as wrens and tits are first order carnivores in this web. The detritus web of the forest canopy is characterized by termites and other insects which consume decomposing wood. These insects are preyed on primarily by woodpeckers, creepers, and other tree-top insectivorous birds. Owls are the principal top carnivore in the forest canopy, although other raptors may feed there also.

On the forest floor, deer, mice, rabbits, voles, and mountain beaver browse on bark or leafy vegetation. Numerous insects are also primary consumers in this area. The primary consumers of the forest floor detrital web are mostly insects, although some small mammals may feed on this material also. Songbirds, such as wrens, tits, and creepers, are first order carnivores which feed on the numerous insects of the forest floor. Other carnivores include minks, skunks, raccoons, hawks, and owls. (Figure VI-38 illustrates the food web of this habitat type.)

The principal food web in the water habitat type, aquatic or marine, is based on primary production by phytoplankton and subsequent grazing by zooplankton. In fresh water, insects (mostly larvae and nymph stages) are the first order carnivores. Juvenile salmon and trout, stickleback, sculpin, bullhead, and other fish all feed on insect larvae and in turn are consumed by larger fish and birds, such as herons and kingfishers. In saline and brackish waters, primary consumers are represented by planktonic crustaceans, such as copepods, euphausiids, and amphipods, and the planktonic larval stages of innumerable benthic species. Some of these primary consumers are also first order carnivores. The larger zooplankton forms are fed upon by sea anemones, worms, decapods, pelecypods, and small fish. Certain of these are, in turn, consumed by larger fish. The diversity of size and form in the aquatic and marine environments precludes the existence of a food web as simple as that of the forested ecosystem.

Saline, brackish, and freshwater marsh habitats display more simplified food webs than those just described. Marsh vegetation, including sedges, cattails, and bulrushes are the primary producers. Much of the organic material eventually is exported as detritus and forms the basis for food webs in other habitat types (especially in unvegetated mud and sand flats). Primary marsh consumers include insects, herbivorous mammals, and birds. Beaver, mice, voles, sparrows, mallards, and others feed on the seeds, leaves, and stems of marsh vegetation. Insects are preyed upon by swallows and wrens, the small mammals by herons, bitterns, and hawks. All but the largest of these may fall prey to mink that may frequently enter the marsh to feed.

Swamps also support several food webs. The primary production products of leaves and branches may be exploited in the habitat, deposited in the substrate, or exported to the aquatic or marine habitats. Within the canopy, grazing is carried out by insects and seed-eating animals such as sparrows, squirrels, and mice. Detritus feeding in the canopy is represented primarily by termites and other insects that feed on decomposed wood. Insects in the swamp canopy are fed upon by woodpeckers, creepers, wrens, and other birds. The top carnivore in this realm is usually the owl.

On the swamp floor, both grazing and detritus food webs occur. Deer, rabbits, mice, and insects are important browsers in this area. Detritus feeders include insects and rodents. Wrens, tits, and other insectivorous birds are the principal insect predators; carnivores include mink, raccoon, and various raptors.

Eelgrass habitats support an extremely diverse and complex food web. That food web is based on primary production by eelgrass and numerous epiphytic organisms associated with eelgrass, and also on detrital forms associated with both eelgrass and its epiphytes.

Eelgrass is directly grazed upon by waterfowl, especially black brant, widgeon, scaup, and mallard. Small crustaceans such as the amphipods and isopods and other invertebrates also utilize eelgrass as a food source.

Eelgrass provides a substrate for a variety of diatoms and epiphytic macroalgae. These algae are consumed by zooplankton, small crustaceans, and grazing gastropods. Larger crustaceans, including shrimp, feed on the smaller organisms and all are preyed upon by crabs and small fish, such as herring and juvenile salmon. Crabs and small fish are a food source for large fish, birds and man.

Detritus from eelgrass beds supports a large and diverse food web, perhaps more diverse than the standing crop food web. Detritus undergoes decomposition, soon after disassociating from the plant, that results in physical alteration and nutrient enhancement. Detritus either remains in the eelgrass habitat, or is exported by tidal action or currents to mudflats and other nearby habitats. In either case, it becomes a major food source for a wide variety of benthic invertebrates, including molluscs, detritus-feeding worms, and crustaceans. Detritus feeders are fed upon by shorebirds, waterfowl, and fish (especially herring, juvenile salmon, and other small fish). Many molluscs, crustaceans, and fish that are harvested by man for commercial and sport purposes also utilize eelgrass beds as nursery grounds.

The algae habitat type supports both grazing and detrital food webs. These food webs are based primarily on *Ulva lactuca* and *Enteromorpha intestinalis* as primary producers, although some red and brown algae may also be present. These algae are consumed by waterfowl, such as black brant and mallards, and small fish, including the buffalo sculpin. Waterfowl are popular game for man; small fish are preyed upon by larger fish, diving birds (such as grebes and mergansers) and wading birds such as herons. The algal detrital food web is similar to the eelgrass detrital web.

Mud and sand flats exhibit variable primary production, and very high secondary production from detritus consumption. Primary production in these habitats is principally from benthic diatoms and blue-green algae. These microscopic algae, and the zooplankton which feed upon them, are consumed (along with extensive amounts of detritus) by numerous sediment dwellers. These benthic detritivores include benthic worms, amphipods, ghost and mud shrimps, *Macoma* clams and occasional insect larvae. This diverse mudflat fauna is the principal food source for a wide variety of shorebirds, such as sanderlings, dunlin and sandpiper, and small fish, especially herring, smelt and juvenile salmon. Flounder, sole, and perch also feed on mudflats. Many of these fish are harvested by man, or consumed by fish harvested by man.

Unvegetated and sparsely vegetated dunes typically have a low primary production from sparse beach grasses or dune shrubs. In addition, detrital material transported to the beach supports beach insects, but not in great numbers. These insects in turn are consumed by small insectivorous birds. Mice, voles, and rabbits are all important primary consumers in dune habitat types. These, in turn, are preyed upon by foxes, coyotes, and raptors.

Summary

Primary production in the Humboldt Bay ecosystem is performed by terrestrial plants, wetland plants, aquatic macrophytes (including algae and eelgrass) and phytoplankton. Each of these primary producers forms the foundations of food webs within the estuary ecosystem. Pathways within these food webs may be interwoven and overlap, but may also be analyzed separately.

Terrestrial plants are the basis of an upland grazing food web. Numerous herbivores, including insects, rodents, songbirds, and deer consume the leaves, seeds and stems of upland plants. These herbivores, in turn, are the prey of diverse carnivores, such as mink, raptors, and humans. The products of decomposition and excretion are metabolized in the soil by bacteria, fungi, and other organisms. As the organic materials are decomposed, nutrients are released and made available for recycling within the ecosystem. Upland production products which are transported to the aquatic area, contribute to the detrital food web.

Wetland plants are not extensively utilized by grazers; most wetland production becomes detritus and is transported to aquatic areas. Detritivores in aquatic and marine areas include molluscs and other filter feeders, and amphipods, polychaetes and other sediment feeders. Each of these benthic invertebrate groups are a major food source for crustaceans, a wide variety of fish and birds. Those carnivores, such as crabs, salmon, and sole, are a food source for wading birds, raptors, and humans.

Aquatic macrophytes, such as algae and eelgrass, are primary producers in both the estuarine grazing food web and the detritus based food web. Invertebrates and small fish graze directly on algae and eelgrass, and in turn are consumed by larger fish and crustaceans. These carnivores may also be components of the detritus food web.

Phytoplankton form the basis for a second aquatic grazing web. These microscopic primary producers are the food source of zooplankton, which in turn are consumed by a variety of filter feed-

ing fish and invertebrates. The aquatic grazing food web overlaps with the detritus and macrophytic food webs, since the same carnivores utilize primary consumers from all three food webs.

Thus, although the various food webs may be based on primary production from specific sources, they are not necessarily limited to those sources. In addition, many consumers may be found in a variety of food webs. It is apparent that the food webs of different habitat types are interrelated in a complex, often unknown manner.

T. NUTRIENT CYCLING

A nutrient can be defined as any substance that is used by an organism for growth or sustenance. The significance of a specific nutrient to the ecosystem is determined primarily by its availability to, and its requirement by, organisms within the system. In most ecosystems, the principal essential nutrients are carbon, nitrogen, phosphorus, oxygen, and hydrogen. Other nutrients required by organisms in measurable amounts are potassium, calcium, sulfur, and magnesium. In addition, many substances are required only in trace amounts; some of these are: iron, manganese, copper, zinc, sodium, chlorine, cobalt, and iodine.

Nutrients move through the ecosystem food webs in much the same way as energy. However, unlike energy, which is ultimately lost as heat, nutrients are recycled through a variety of pathways and eventually returned to the food webs. This discussion will describe in a simplified way, the recycling of nutrients in an estuarine ecosystem, and also has some application to the global ecosystem.

Although many nutrients have been identified, the complete cycles of only a few have been clearly delineated. Fewer still have been subjected to quantitative analysis in order to measure their kinetics and movement through the global ecosystem. For these reasons, only three of the most important nutrients will be considered. Carbon, nitrogen, and phosphorus have been the most carefully studied and are the best understood of the nutrients. In addition, nitrogen and/or phosphorus are often considered "limiting"; that is, they are nutrients which limit the population size of an organism or group of organisms if certain quantities are not present. It is the limiting nature of these nutrients which make an understanding of their movement through the ecosystem important. Descriptions of nutrient cycling pathways are intended to provide a basic understanding of nutrient cycling in the estuarine ecosystem. Included with the discussion of each nutrient is a diagram illustrating the cycling pathways described in the text.

Carbon

The carbon cycle is closely related in a quantitative way to energy transfer through an ecosystem, since the light energy converted by primary producers during photosynthesis is incorporated into a variety of organic compounds containing carbon. The carbon atom is recycled and is ultimately returned to the atmosphere as CO_2 . The carbon cycle is illustrated in Figure VI-39.

The CO_2 assimilated in the photosynthetic reaction may be extracted from the atmosphere (in the case of terrestrial plants) or from water (in the case of phytoplankton). Carbon thus assimilated

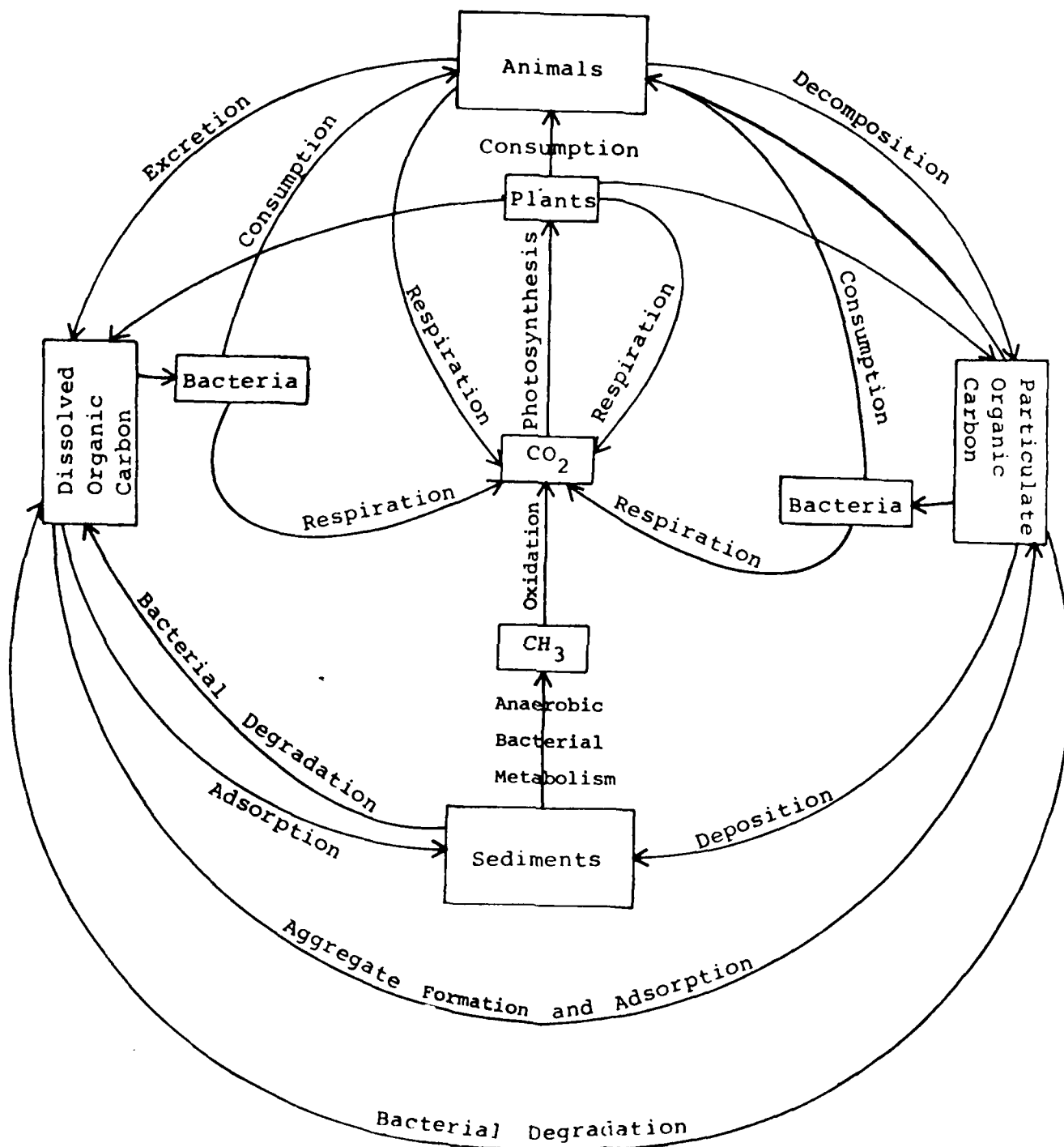


Figure VI-39

THE ESTUARINE CARBON CYCLE
(after Champ, 1977)

is used by the primary producer for maintenance (respiration), for the formation of structural compounds, or for energy storage. If the plant is consumed, the herbivore converts the plant carbon compounds to animal carbon compounds which are used for maintenance (respiration), structural components or storage. If the herbivore is consumed, the organic compounds are used by the carnivore for maintenance, structural components or storage. In each step, the metabolism of organic compounds results in the release of CO_2 which is then returned to the atmosphere or water.

Any carbon consumed but neither assimilated nor respired will be excreted. Organisms not consumed eventually die, and their tissues are then transformed, through various physical and biological processes, into detritus. Excrement and detritus ultimately yield dissolved, or particulate, organic carbon. Both forms of organic carbon may reenter a food web through assimilation by plants, bacteria, detritus feeders, or other organisms. They may also be incorporated into sediments and thus enter a detritus food web.

Oxidation of organic carbon will take place in anaerobic sediments by microbial fermentation reactions. These reactions can lead to the production of various intermediates such as methane gas or, more importantly, dissolved organic carbon. Under reduced pH and anaerobic conditions and when the organic carbon content of the sediments is high, fermentation reactions may be augmented by sulfur reactions, resulting in putrefaction and accumulation of H_2S .

In addition to organic carbon, sediments may receive inorganic carbonates that had been incorporated into structural components by consumers or eroded from geologic sources. Shells, teeth, and bones are physically altered and deposited in sediments with other carbonates and organic carbon. In aquatic environments, particulate carbonate sediments may add to, or remove, dissolved inorganic carbonate and CO_2 in the water column through chemical reactions.

An estimated 90% of marsh production is converted to detritus (Gunnison, 1978) or assimilated by detritivores in which case it forms the basis of a major aquatic food web. In upland and aquatic food webs, however, most plant production is converted to animal carbon through grazing.

Most organic carbon deposited in uplands is ultimately utilized by decomposers and returned to the food web; that which is deposited in marshes or swamps is often buried before decomposition, forming peat. Both organic carbon and inorganic carbonate may be buried in aquatic sediments.

Phosphorus

The phosphorus cycle is relatively simple. There is only one significant inorganic form of the nutrient, phosphate (PO_4), and no atmospheric forms; as a result, its cycling is associated only with the soil and water components of the ecosystem. In addition, virtually all organisms can convert organic phosphorus to phosphate.

Phosphorus is of fundamental importance to physiological functions and is required in relatively high concentrations by most organisms. Traditionally, phosphorus has been identified as the critical limiting nutrient in freshwater ecosystems. However, it is not considered to be limiting in marine waters. Figure VI-40 describes the estuarine phosphorus cycle.

The principal source of phosphorus is phosphate-bearing rocks that are eroded into various waters. In addition, it has been estimated that detergents and municipal wastes may represent 25-50% of the total land-derived phosphates. Dissolved inorganic phosphate is taken up by primary producers and micro-organisms; it is then moved up the food chain as organic phosphate. Dissolved phosphate which is not assimilated moves downstream and ultimately may be deposited in shallow sediments such as marshes or tide flats and may be assimilated by rooted plants or detritus feeders, and reenter the food web. Additionally, in shallow systems there appears to be an exchange of phosphate between sediments and water (Gunnison, 1978). Phosphates deposited in deep ocean sediments are considered lost unless uplifted by geologic forces.

Nitrogen

Nitrogen is an important nutrient in biological ecosystems, since it is a major constituent of protein, nucleic acids, and other cellular macromolecules. Because of their predominantly protein, rather than carbohydrate, structure, animals tend to have greater amounts of nitrogen than plants. In marine waters, nitrogen, not phosphorus, is usually considered to be the limiting nutrient (Clark, 1974; Rhyther and Dunstan, 1971).

The nitrogen cycle is very complex, involving four inorganic forms and a variety of specialized bacteria. Figure VI-41 illustrates the various aspects of nitrogen cycling through the ecosystem.

Atmospheric molecular nitrogen (N_2) (and nitrogen dissolved in water) is the most abundant form, but in this form it can be used by only a few types of organisms. Nitrogen fixation, the conversion of N_2 to nitrates (NO_3), is accomplished only by certain algae and bacteria. Nitrates generated by these organisms may then be incorporated by primary producers into organic compounds. Nitrogen-fixing organisms may also be incorporated into the food web through consumption, or death and decomposition.

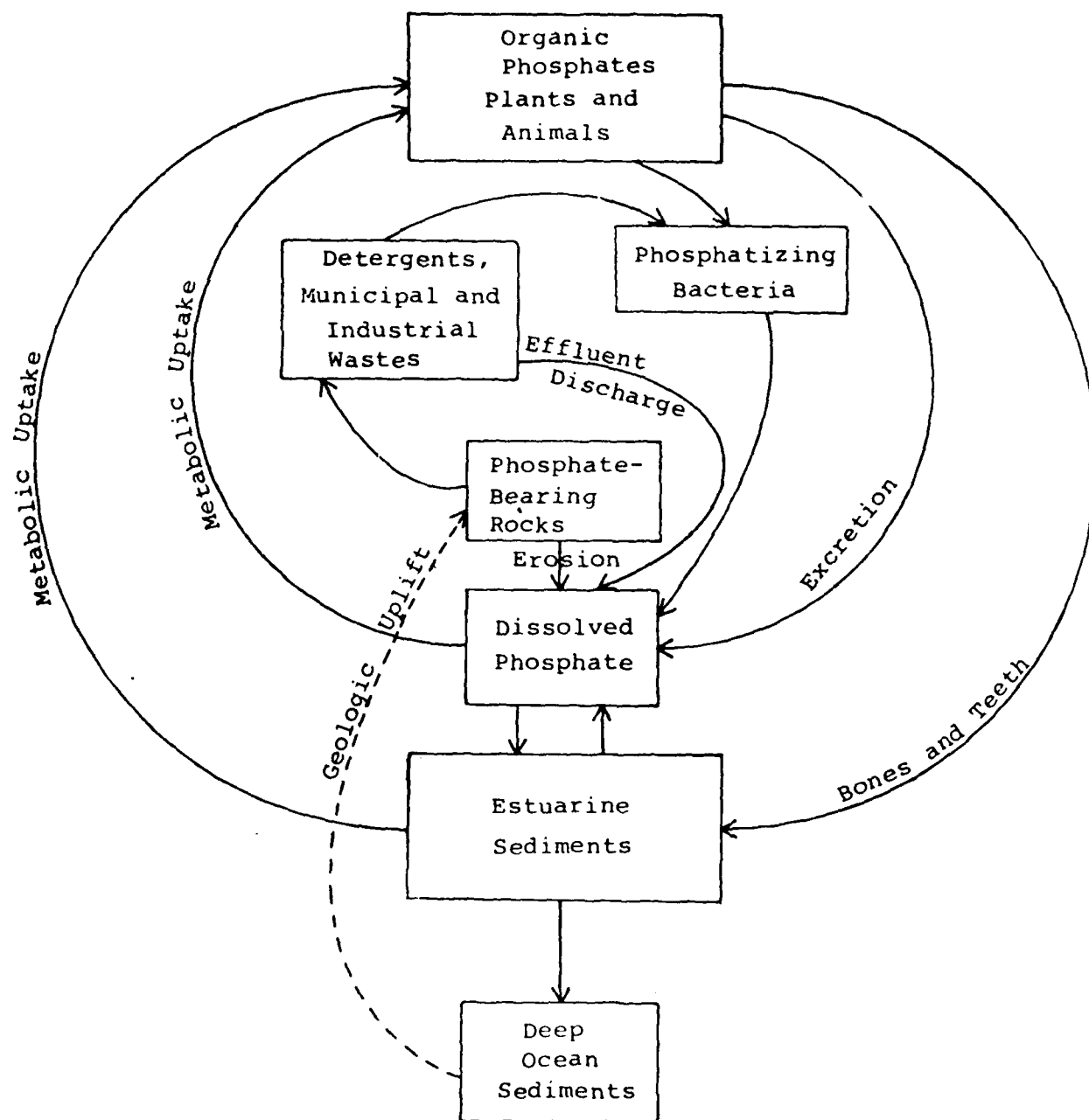


Figure VI-40

THE PHOSPHORUS CYCLE
(after Champ, 1977, and Odum, 1971)

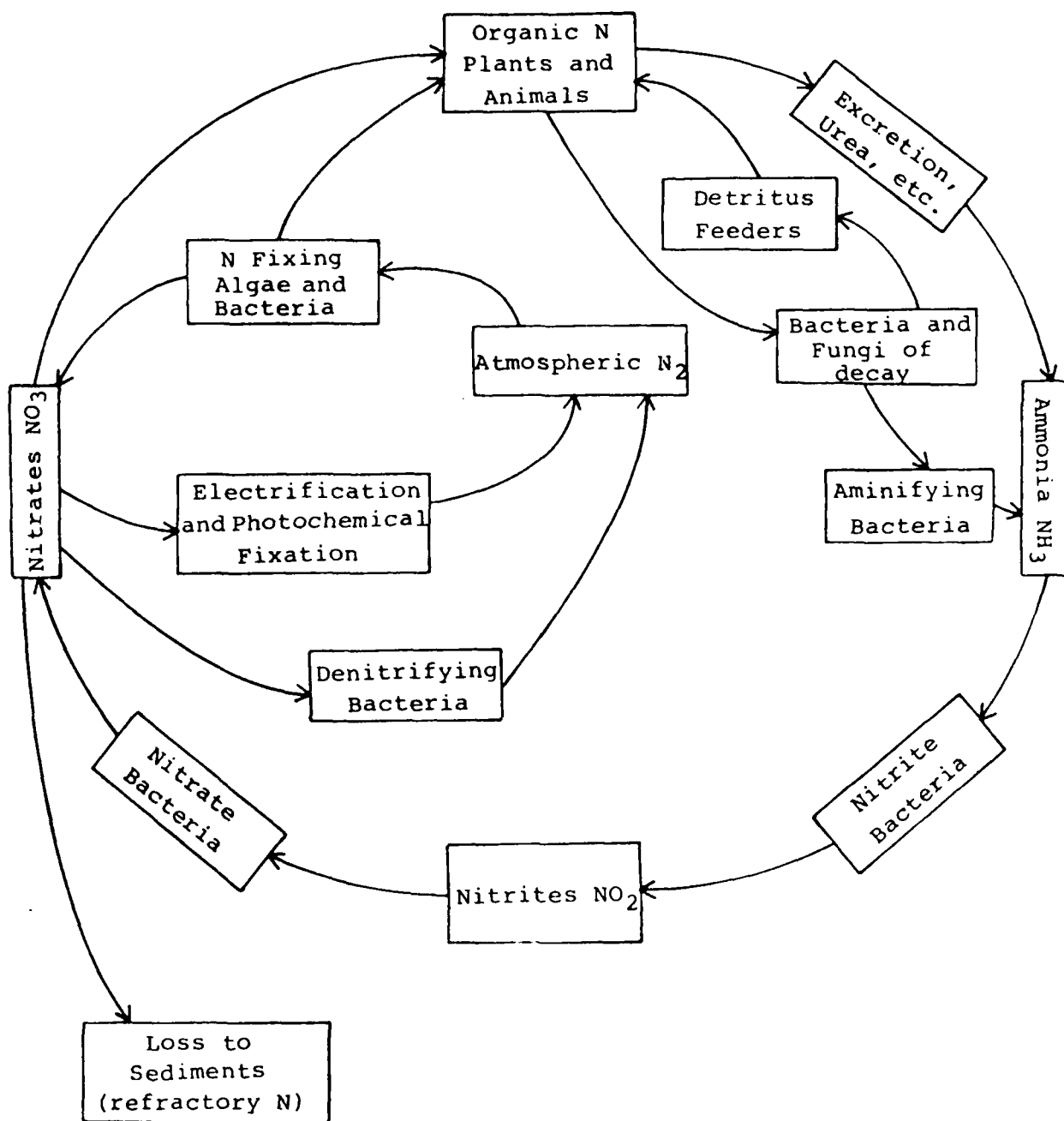


Figure VI-41

THE ESTUARINE NITROGEN CYCLE
(modified from Odum, 1971)

Marine grasses also make an important contribution to nutrient cycling. Eelgrasses (Zostera) are rooted in sediments, and take up nutrients through root hairs. The anaerobic sediments surrounding the roots contain micro-organisms that can fix atmospheric nitrogen, thus creating a ready nitrogen supply for the eelgrass, and a relatively stable source of nitrogen compounds for herbivores.

Detritus, one of the products of decomposition, contains an estimated 50% of the non-gaseous nitrogen in the ecosystem (Ricklefs, 1973). Thus, the conversion of this material to organic compounds in the food web is an important process. Some is consumed by detritus feeders, the remainder undergoes complete decomposition, where the organic nitrogen is converted to ammonia (NH_3) by aminifying bacteria. Other bacteria convert ammonia to nitrites (NO_2) and nitrites to nitrates. The nitrates are then available for assimilation by primary producers. It should also be noted that some nitrate is converted to molecular nitrogen by sediment-dwelling anaerobic bacteria that does not require free oxygen to carry on metabolic reactions.

Under certain conditions, nitrogen containing compounds can be toxic to marine and freshwater organisms. Ammonia, for example, comprises from 40 to 90% of the nitrogenous excretions in crustaceans and may be considered a toxic metabolite when the animals are crowded. The nitrates, however, are believed to be relatively non-toxic to most aquatic organisms. While accumulations of these substances above normal limits are unlikely in a well-buffered natural aquatic environment, they can become significant in closed systems (i.e., ponds) with high nutrient impacts. In such systems, nitrate/nitrite/ammonia toxicity can be exacerbated by pH increases, temperature increases, or salinity decreases.

Summary

The three principal nutrients, carbon, phosphorus, and nitrogen, cycle through the estuarine ecosystem in very different and complex ways. The atmosphere is the primary source for carbon and nitrogen, but there is no major atmospheric form of phosphorus. All three nutrients can be lost to the ecosystem as a result of deposition in deep-ocean sediments.

Terrestrial primary producers acquire carbon directly from the atmosphere and absorb dissolved phosphorus and nitrogen from water and sediment (aquatic primary producers absorb all nutrients from water and sediments). Phosphorus is available directly from erosion and dissolution of rocks; nitrogen must be fixed from the atmosphere or extracted from detritus and converted to nitrate before it is available to most primary producers.

Once assimilated by primary producers, nutrients move through the various trophic levels of the food web in the same manner as energy. Cellular respiration and metabolic processes associated with decomposition and excretion processes ultimately act to recycle nutrients. Cellular respiration results in carbon being returned to the atmosphere as CO_2 . Decomposition processes yield particulate organic carbon and particulate phosphate which may be deposited as sediments in marshes, swamps, tide flats, and eelgrass beds. Decomposition also initiates the process of converting organic nitrogen to nitrate. Excrement contains high concentrations of soluble nutrients which are immediately available to some micro-organisms. Through these micro-organisms, nutrients either reenter the food web directly or are converted to compounds which can be utilized by primary producers.

Nutrients enter the estuary food web through a variety of means, and each specific nutrient that moves through the food web constitutes only a small fraction of the entire nutrient cycle. Decomposition and detritus formation are important processes in nutrient cycles, returning nutrients to the primary producers in a form they can incorporate.

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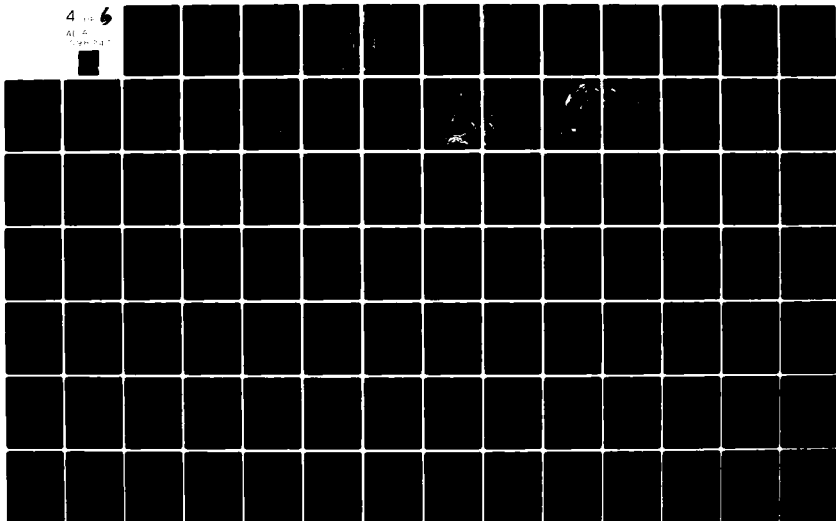
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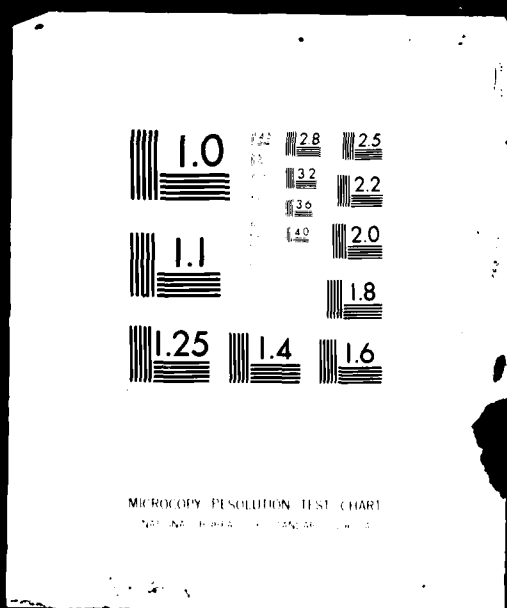
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Section VII

LAND USE AND GOVERNMENTAL PROFILES

A. LAND AND WATER USE

As an area grows and develops, patterns and trends of land use change may be identified. A knowledge of these patterns and trends, and of the extent of land use change, is important in understanding how, when, and what sort of future changes in land use may occur.

The purpose of this section is four-fold:

- 1) To map existing (1978) land, water, and wetland use in the study area
- 2) To identify historic land use trends and changes
- 3) To identify existing wetlands and historic wetlands changes
- 4) To identify shoreline changes over time

The basic method used in obtaining this data was aerial photograph interpretation and planimetry. A detailed description of the methodology is given in the Technical Appendix, Section IX.E. Briefly, aerial photographs of the study area for the years 1948, 1958, 1969, 1976, and 1978 were assembled, and photo interpretation maps of land use by year were made. These maps were then planimetered to obtain acreage amounts for various types of land use. In addition to aerial photographs, old U.S. Coast and Geodetic Survey maps for the years 1871, 1903 and 1926 were obtained from the National Archives in Washington, D.C. and were planimetered for acreage by land use category. Additional maps for the years 1852, 1886, 1891, 1927, 1930, 1931, 1935, and 1941 were reviewed qualitatively. The land use categories used in photo and map measurement are listed and described in Table VII-1.

Table VII-1

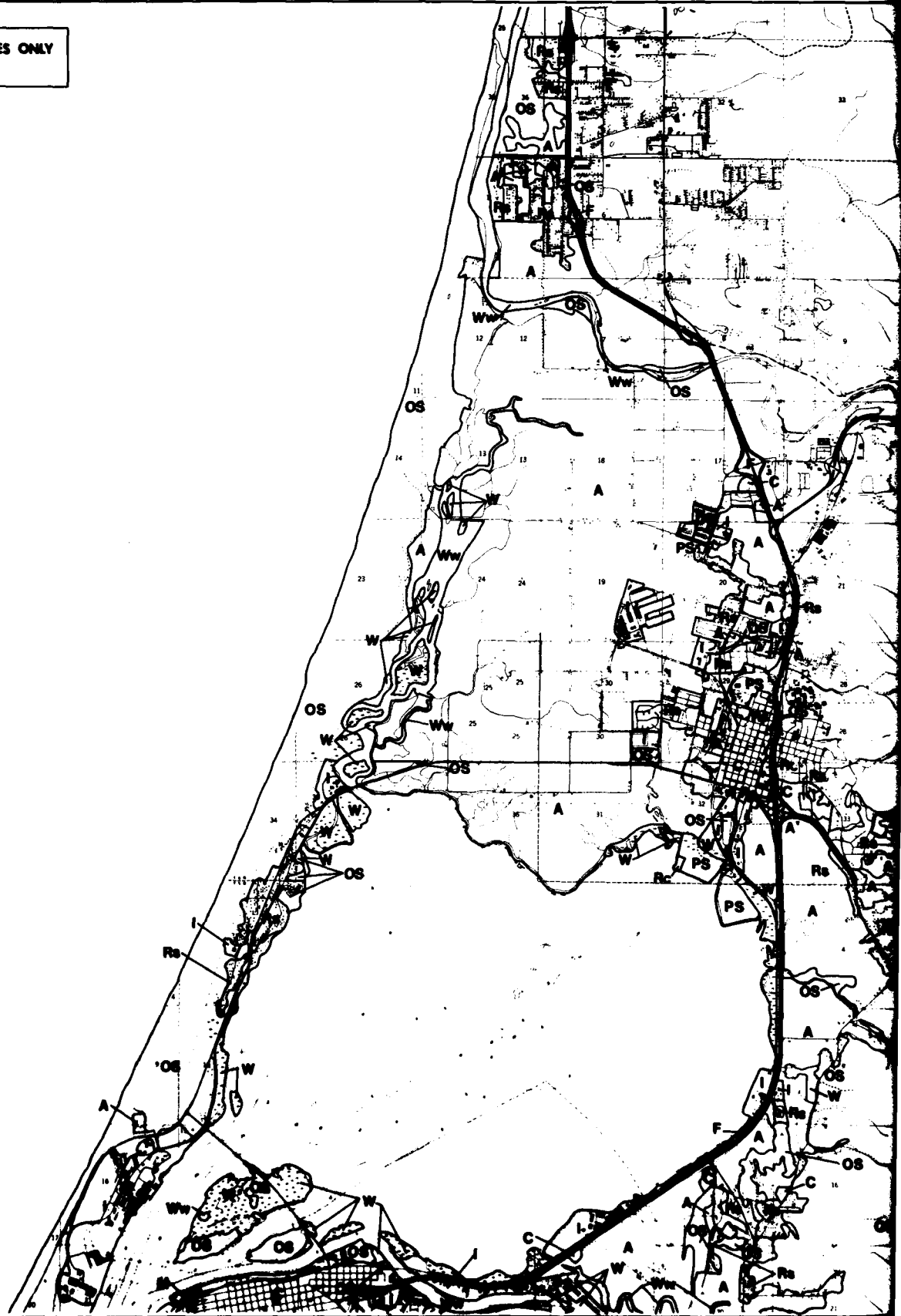
LAND USE CATEGORIES

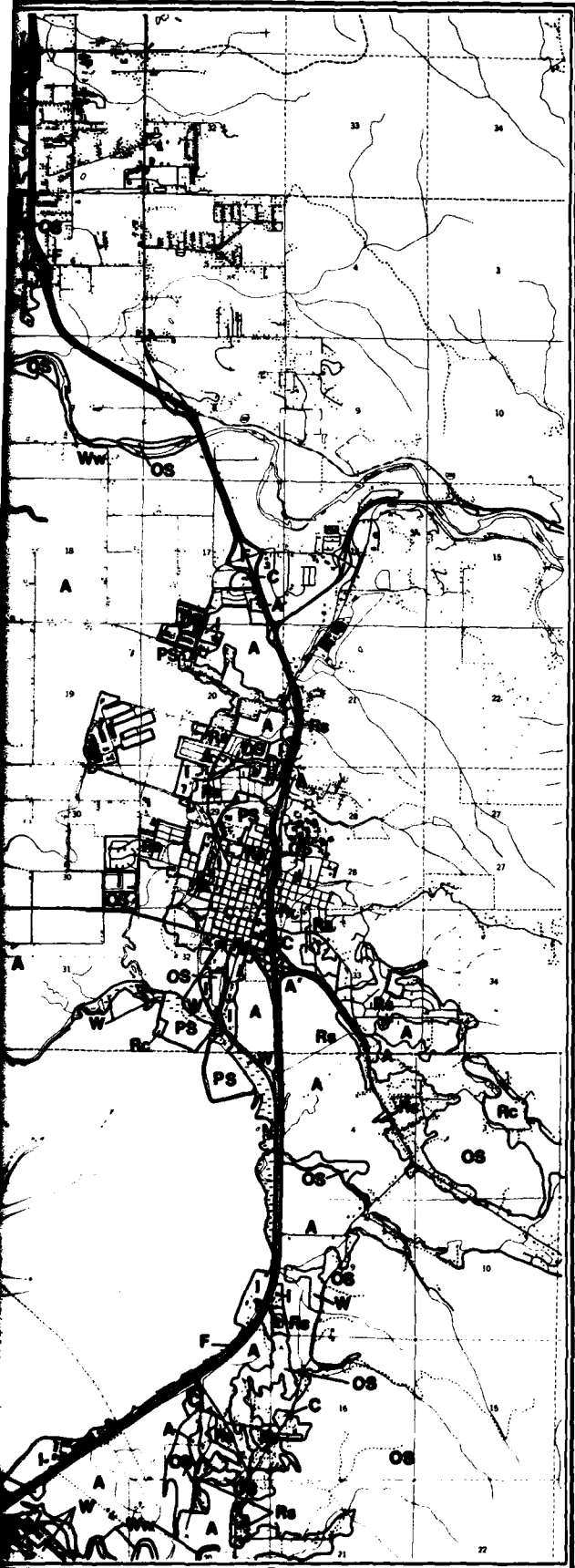
Open Space (OS)	Any woodland, or any grassland which was not agriculture. May include occasional houses in sparsely populated areas.
Wetland (W)	Any marsh or swamp.
Agriculture (A)	Any areas used for pasture or row crops. May include occasional houses in sparsely populated areas.

Commercial (C)	Urban non-industrial and non-residential development, downtown areas of cities, neighborhood business.
Industry (I)	Any manufacturing business, includes port facilities, lumber mills, boat building, and parking areas associated directly with a specific business.
Residential (Rs)	Single family or multiple family dwellings, density greater than 1 unit per acre.
Waterways (Ww)	All natural water bodies in the area such as sloughs, creeks and ponds. The Bay waters are not included; the category Ww stops at the mouth of the creek or slough.
Public Services (PS)	Sewage treatment ponds, pipeline corridors, power line corridors, military installations, schools, hospitals, cemeteries, airports.
Recreation (Rc)	Parks and boat launch ramps. Marinas were identified separately.
Marina (M)	Areas for mooring or storing boats.
Freeway (F)	Major local, state and federal highways.
Log Rafting (LR)	In-water log storage areas, including sloughs and mill ponds.
Log Storage (LS)	Log storage areas on land.
Railroad (RR)	Railroad tracks, switching yards and maintenance facilities.
Gravel Bar (GB)	Deposits of gravel exposed during low water along the Mad River.
Mudflat (MF)	Intertidal areas of mud and sand, generally located adjacent to the Bay shore.
Fill	Sanitary landfill.
Unknown	Areas for which no map or photo coverage was available.

Plate 14 shows the relative size and location of 1978 land uses in the study area, mapped from color IR aerial photographs at

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LAND USE 1978

PLATE NO 14 NORTH

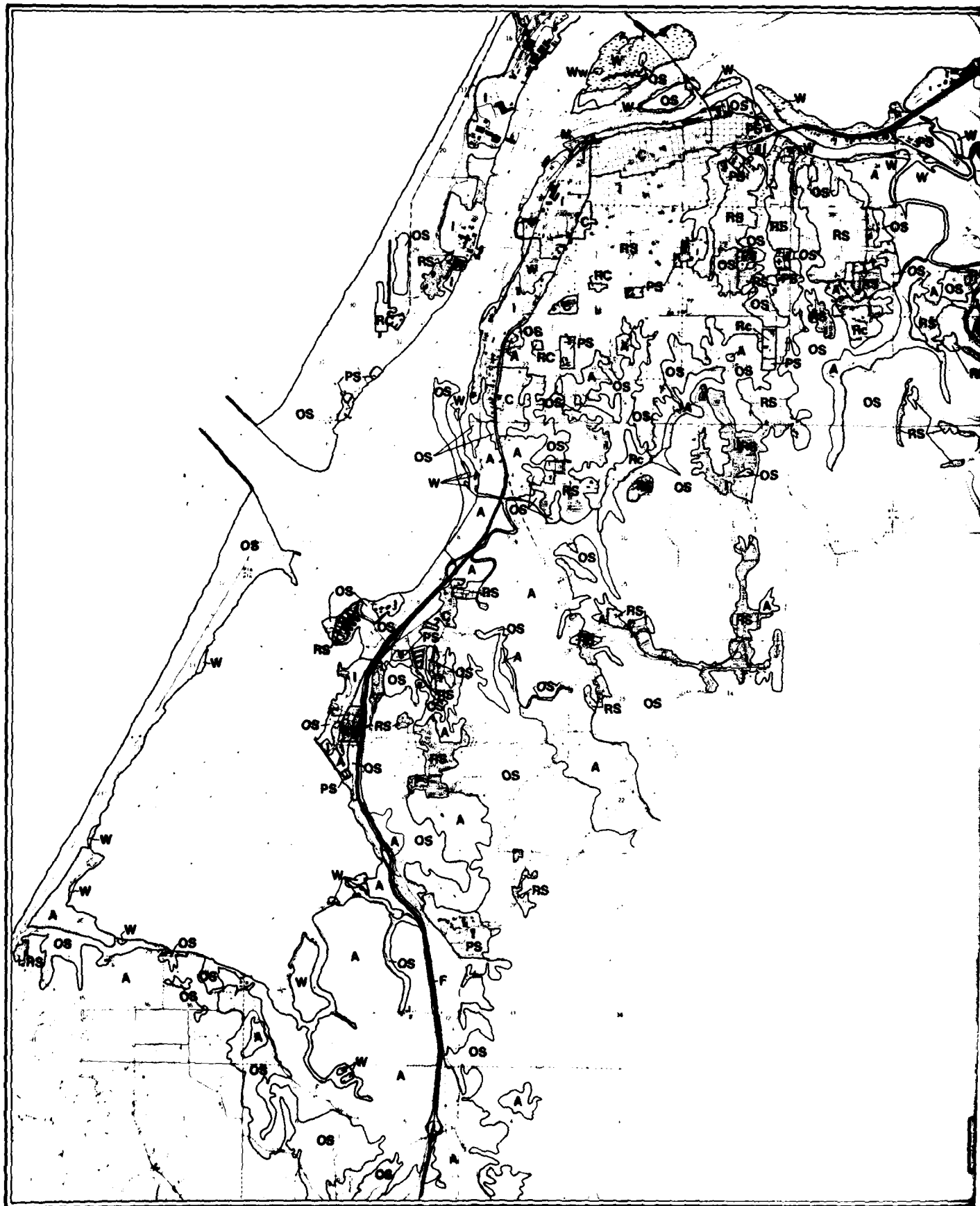
LEGEND

- A** Agriculture
- C** Commercial
- F** Freeway
- I** Industry
- M** Marina
- OS** Open Space
- PS** Public Service
- Rc** Recreation
- Rs** Residential
- W** Wetland
- Ww** Waterway



**HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS**

2



LAND USE 1978

PLATE NO 14 SOUTH

LEGEND

- A Agriculture
- C Commercial
- F Freeway
- I Industry
- M Marina
- OS Open Space
- PS Public Service
- Rc Recreation
- Rs Residential
- W Wetland
- Ww Waterway



HUMBOLDT BAY WETLANDS REVIEW
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BAYLANDS ANALYSIS

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1:24000. Agriculture is a major land use in Arcata Bottoms, Bayside Bottoms, Eureka Slough, Elk River, Table Bluffs, and Beatrice Flats. The entire South Spit and much of the North Spit are open space, as are the Eureka gulches and Martin Slough. The North Spit coastal dunes are all open space. Wetlands occur principally in the Mad River Slough, along the North Bay shoreline near Manila, and from Arcata to Eureka, on the Islands, and scattered through the Broadway area, Elk River, and Beatrice Flats. Industrial uses are concentrated in Arcata, the Eureka waterfront, the Eureka-Bucksport strip, and Fields Landing and on the North Spit south of the Eureka-Samoa bridge. Residential uses occur in cities and small communities around the Bay (see Section VIII.a, Cultural Resources).

The following tables (VII-2 to VII-8) show land use by type and by subarea for the years 1978, 1969, 1958, 1948, 1926, 1903, and 1871. Certain land use categories have been aggregated; marinas are included in Recreation, and Freeways, Log Storage, Log Rafting, Railroad, Gravel Bar, Mudflat, Fill, and Unknown are included in an "other" category. The specific categories included in Other are identified for each year. The waters of the Bay are not included in Waterways.

Land use by year for the study area is summarized in Table VII-9 for the years 1871, 1948, 1958, 1969, and 1978 (1926 and 1903 are not included because about 6500 acres of the study area in the Arcata Bottoms subarea had no map coverage for those years. The totals do not include Mad River subarea because map and photo coverage was only available for 1871, 1969, and 1978). In 1871 most of the study area lands (about 80%) were in open space and wetlands, with agriculture using about 3000 acres. By 1948 agriculture had increased in land area over 5 times to a high of about 17,000 acres. Only about 50% of the open space and 15% of the wetlands remained.

TABLE VII - 9

LAND USE BY YEAR (ACRES)

<u>Year</u>	<u>Open Space</u>	<u>Agriculture</u>	<u>Wetland</u>	<u>Commercial & Industrial</u>	<u>Residential</u>
1871	17269	3049	8738	0*	250
1948	8573	17302	1337	1048	2332
1958	8467	14905	1136	1595	3616
1969	8650	13657	1128	2265	3977
1978	8372	13750	1108	2239	4171

* There were probably some mills in existence in 1871, but none are identified on the 1871 map.

Source: Interpretation of aerial photos and maps, Shapiro & Associates, Inc., 1979.

Land Use, Humboldt Bay Study Area, 1978
(Area in Acres)

Others include: (1) Freeway, (2) Mudflats

Subarea	Open Space	Agriculture	Wetland	Commercial	Industrial	Residential	Waterway	Public Service	Recreation	Other	TOTAL
Mad River	508	564	-	-	-	287	174	-	-	-	1533
Arcata Bottoms	1398	6113	246	95	331	546	489	141	7	(2) 7	9373
North Spit	2594	7	149	-	530	191	-	67	46	-	3584
Bayside Bottoms	151	1020	55	6	49	87	-	-	-	(1) 70	1438
Eureka Slough	809	2207	194	19	196	672	197	67	58	(1) 32	4451
Eureka	333	147	6	372	440	1377	-	102	14	-	2791
Islands	93	-	255	-	-	-	-	-	-	-	348
Elk River	1799	1880	30	40	161	1298	119	151	117	(1) 24	5619
Beatrice Flats	79	1781	122	-	-	-	113	-	-	-	2095
Table Bluff	217	499	-	-	-	-	-	-	-	-	716
South Spit	899	96	51	-	-	-	-	-	-	-	1046
TOTAL	8880	14314	1108	532	1707	4458	1092	528	242	133	32994

Source: Aerial photo interpretation and measurement, Shapiro & Associates, Inc., 1979.

Table VII - 3.

Land Use, Humboldt Bay Study Area, 1969
(Area in Acres)

Other includes (1) Freeway, (2) Mudflats, (3) Log Storage, (4) Fill, (5) Railroad, (6) Log Rafting

Subarea	Open Space	Agriculture	Wetland	Commercial	Industrial	Residential	Waterway	Public Service	Recreation	Other	TOTAL
Mad River	634	541	-	-	11	250	-	-	-	-	1436
Arcata Bottoms	1458	6238	229	-	448	428	264	105	-	(2,3,4) 212	9382
North Spit	2609	-	111	-	382	166	-	72	-	(2,3,6) 177	3517
Bayside Bottoms	83	1141	-	-	74	9	-	-	-	(1) 83	1390
Eureka Slough	732	2096	235	75	281	708	184	53	-	(1,3) 86	4450
Eureka	419	-	77	-	867	1396	-	3	-	(5) 28	2790
Islands	90	-	266	-	-	-	-	-	-	-	356
Elk River	2025	1774	22	2	134	1270	129	6	-	(3) 66	5428
Beatrice Flats	260	1723	18	-	-	-	90	-	-	-	2091
Table Bluff	127	589	-	-	-	-	-	-	-	-	716
South Spit	847	96	40	-	-	-	-	-	-	-	983
TOTAL	9284	14198	1128	77	2197	4227	667	239	-	652	32539

Source: Aerial photo interpretation and measurement, Shapiro & Associates, Inc., 1979.

Land Use, Humboldt Bay Study Area, 1958
(Area in Acres)

Other includes (1) Freeway, (2) Mudflats, (3) Log Rafting, (4) Gravel Bar, (5) Unknown, (6) Railroad

Subarea	Open Space	Agri-culture	Wetland	Commer-cial	Indus-trial	Resi-dential	Waterway	Public Service	Recre-ation	Other	TOTAL
Mad River	Unknown, no aerial coverage										-
Arcata Bottoms	1445	6409	282	21	388	366	340	66	6	(3,4) 51	9384
North Spit	2849	-	150	-	160	139	-	75	-	(3) 63	3436
Bayside Bottoms	111	1096	99	8	26	16	-	-	-	(1) 70	1426
Eureka Slough	864	2293	147	-	136	518	391	6	22	(1,3,6) 78	4455
Eureka	313	207	31	173	525	1509	-	4	7	(6) 21	2790
Islands	104	-	267	-	-	-	-	-	-	-	371
Elk River	1528	2603	17	11	137	1058	97	-	-	(1,2,3,5) 46	5497
Beatrice Flats	189	1641	136	-	-	10	117	-	-	-	2093
Table Bluff	154	560	2	-	-	-	-	-	-	-	716
South Spit	910	96	5	-	-	-	-	-	-	-	1011
TOTAL	8467	14905	1136	223	1372	3616	945	151	35	329	31179

Source: Aerial photo interpretation and measurement, Shapiro & Associates, Inc., 1979.

TABLE VII - 5

Land Use, Humboldt Bay Study Area, 1948
(Area in Acres)

Other includes (1) Gravel Bar, (2) Log Storage, (3) Log Rafting

Subarea	Open Space	Agriculture	Wetland	Commercial	Industrial	Residential	Waterway	Public Service	Recreation	Other	TOTAL
Mad River	Unknown	no aerial coverage									-
Arcata Bottoms	1401	6879	440	89	199	290	-	-	-	(1) 7	9305
North Spit	3021	-	172	-	39	-	-	74	-	(2,3) 73	3379
Bayside Bottoms	92	1258	47	-	-	-	-	-	-	-	1397
Eureka Slough	847	3171	153	-	-	169	18	52	33	-	4443
Eureka	465	364	77	227	358	1274	-	-	5	(1) 20	2790
Islands	110	-	264	-	-	-	-	-	-	-	374
Elk River	1548	3055	50	-	136	599	120	-	-	-	5508
Beatrice Flats	-	1858	115	-	-	-	131	-	-	-	2104
Table Bluff	95	621	-	-	-	-	-	-	-	-	716
South Spit	99'	96	19	-	-	-	-	-	-	-	1109
TOTAL	8573	17302	1337	316	732	2332	269	126	38	100	31125

Source: Aerial photo interpretation and measurement, Shapiro & Associates, Inc., 1979.

TABLE VII -- 6

Land Use, Humboldt Bay Study Area, 1926
(Area in Acres)

Subarea	Open Space	Agri- culture	Wetland	Commer- cial	Indus- trial	Resi- dential	Waterway	Public Service	Recre- ation	Other	TOTAL
Mad River	Unknown	no map	coverage								
Arcata Bottoms	301	1910	306	-	-	326	-	-	-	(1) 6529	9372
North Spit	3165	42	36	-	-	53	-	-	-	-	3296
Bayside Bottoms	298	1002	96	-	-	22	34	-	-	-	1452
Eureka Slough	1707	1880	655	-	-	24	205	-	-	-	4471
Eureka	1115	121	401	197	170	768	-	-	18	-	2790
Islands	58	83	239	-	-	-	-	-	-	-	380
Elk River	3307	1768	24	-	-	36	406	-	-	-	5541
Beatrice Flats	96	1460	525	-	-	-	-	-	-	-	2081
Table Bluff	699	-	17	-	-	-	-	-	-	-	716
South Spit	781	22	83	-	-	-	-	-	-	-	886
TOTAL	11527	8288	2382	197	170	1229	645	-	18	6529	30985

Other includes (1) Unknown

Source: Coast and Geodetic Survey Maps and Measurement, Shapiro & Associates, Inc., 1979.

TABLE VII - 7

Land Use, Humboldt Bay Study Area, 1903
(Area in Acres)

Other includes (1) Unknown

Subarea	Open Space	Agriculture	Wetland	Commercial	Industrial	Residential	Waterway	Public Service	Recreation	Other	TOTAL
Mad River	Unknown	no map coverage.									
Arcata Bottoms	302	734	1725	-	-	94	65	-	-	(1) 6463	9383
North Spit	3103	-	284	-	-	-	45	-	-	-	3432
Bayside Bottoms	432	65	827	-	-	-	42	-	-	(1) 83	1449
Eureka Slough	1983	-	2531	-	-	-	-	-	-	-	4514
Eureka	1844	110	415	-	67	214	123	-	17	-	2790
Islands	-	81	291	-	-	-	-	-	-	-	372
Elk River	3399	1552	193	-	42	-	318	-	-	-	5504
Beatrice Flats	58	-	1965	-	-	-	-	-	-	(1) 106	2129
Table Bluff	698	-	18	-	-	-	-	-	-	-	716
South Spit	814	-	105	-	-	-	-	-	-	-	919
TOTAL	12633	2542	8354	-	109	308	593	-	17	6652	31208

Source: Coast and Geodetic Survey Maps and Measurement, Shapiro & Associates, Inc., 1979.

VII - 8

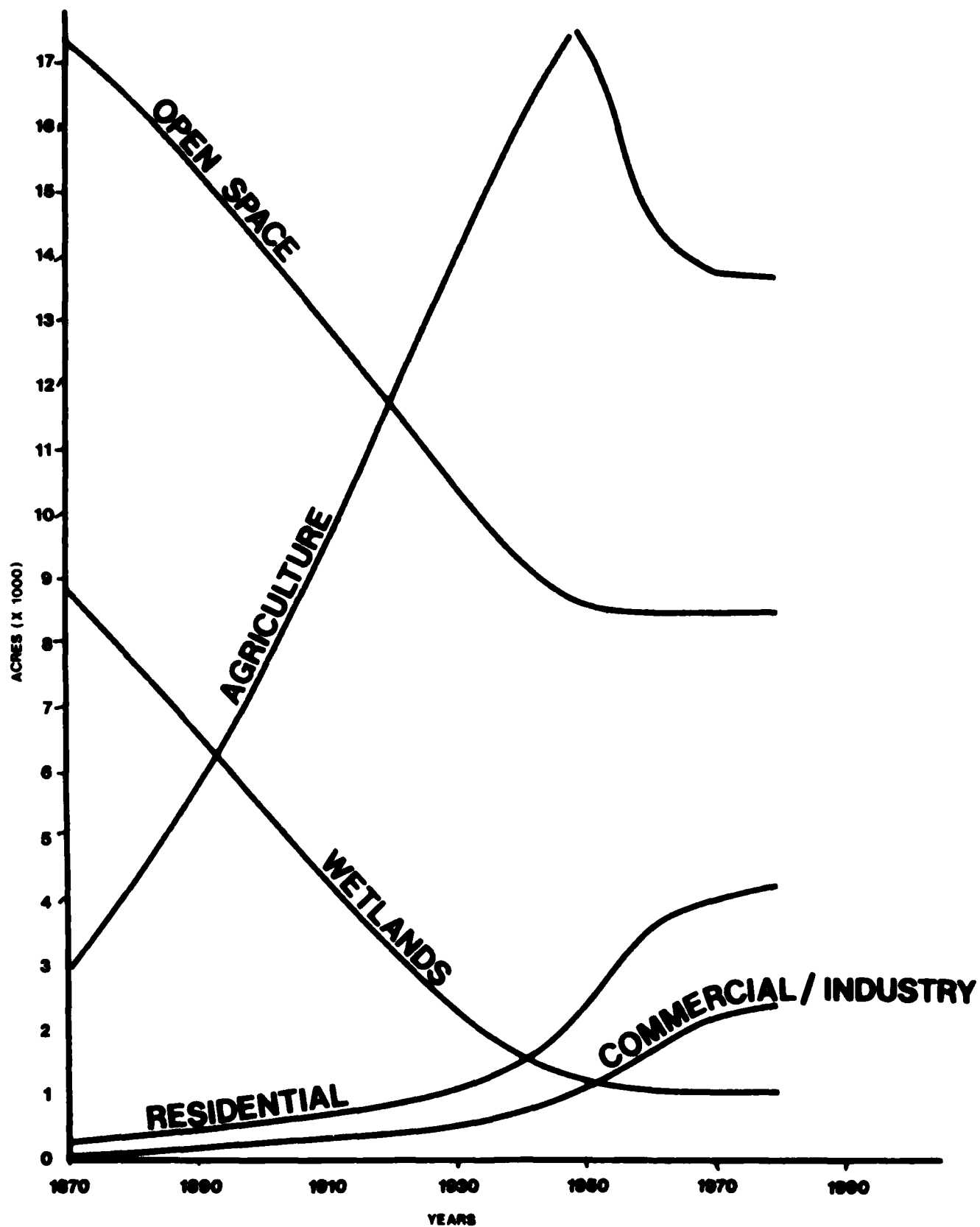
Land Use, Humboldt Bay Study Area, 1871
(Area in Acres)

Subarea	Open Space	Agriculture	Wetland	Commercial	Industrial	Residential	Waterway	Public Service	Recreation	Other	TOTAL
Mad River	1386	8	-	-	-	-	139	-	-	-	1533
Arcata Bottoms	4398	1495	2982	-	-	68	363	-	-	-	9306
North Spit	2886	11	217	-	-	-	29	-	-	-	3143
Bayside Bottoms	507	77	825	-	-	-	25	-	-	-	1434
Eureka Slough	2410	74	1795	-	-	-	213	-	-	-	4492
Eureka	1919	174	488	-	-	182	11	-	16	-	2790
Islands	-	84	257	-	-	-	-	-	-	-	341
Elk River	3770	1111	245	-	-	-	427	-	-	-	5553
Beatrice Flats	92	23	1929	-	-	-	105	-	-	-	2149
Table Bluff	716	-	-	-	-	-	-	-	-	-	716
South Spit	571	-	-	-	-	-	-	-	-	-	571
TOTAL	18655	3057	8738	-	-	250	1312	-	16	-	32028

Source: Coast and Geodetic Survey Maps and Measurement, Shapiro & Associates, Inc., 1979

Urban-type development (commercial, industrial, residential) had shown a 13-fold increase in land area. Over the period 1948-1978 urban-type uses continued to increase, leveling off somewhat after 1969. During this period agricultural uses declined. There was some loss of wetlands (about 200 acres) between 1948 and 1958, but wetland acreage has remained fairly constant since 1958. Figure VII-1 shows the trends in Table VII-9 graphically.

Table VII-10 shows wetland changes over time for each sub-area. The Arcata Bottoms, Eureka Slough, Beatrice Flats, and Bayside Bottoms had large amounts of wetlands in 1871; by 1926 significant losses had already occurred because of diking to allow agricultural uses. In 1978 the following percentages of the 1871 wetlands in the lowland areas remained: Arcata Bottoms, 8%; Bayside Bottoms, 6%; Eureka Slough, 11%; Beatrice Flats, 6%.



LAND USE CHANGES OVER TIME

Figure VII-1

Table VII - 10

Wetlands Changes by Subarea Over Time
(Area in Acres)

<u>Subarea</u>	<u>Years</u>						
	<u>1871</u>	<u>1903</u>	<u>1926</u>	<u>1948</u>	<u>1958</u>	<u>1969</u>	<u>1978</u>
Mad River ¹	0	N/A	N/A	N/A	N/A	0	0
Arcata Bottoms ²	2982	N/A	N/A	440	282	229	246
North Spit	217	284	36	172	150	111	149
Bayside Bottoms	825	827	96	47	99	0	55
Eureka Slough	1795	2531	655	153	147	235	194
Eureka	488	415	401	77	31	77	6
Islands	257	291	239	264	267	266	255
Elk River	245	193	24	50	17	22	30
Beatrice Flats	1929	1965	525	115	136	18	122
Table Bluff	0	18	17	0	2	0	0
South Spit	0	105	83	19	5	40	51

¹ N/A means no map or photo coverage available² N/A means only partial map coverage available

B. LAND AND TIDELAND OWNERSHIPS

The ownership and control of land areas, including tidelands, is one of the factors which determine when, where, and how much development pressure there will be. One of the most important issues in ownership is whether the land or tideland is in public or private holdings. Public ownership is defined as ownership by a Federal, state, or local agency, including special districts (school, etc.). A further complicating issue in tideland ownership is the public trust doctrine. This profile will discuss public and private land and tideland ownership in two parts: (1) Uplands and (2) tidelands/water areas. Information on ownership was obtained from Humboldt County appraisal maps (Humboldt County Assessor's Office, 1979) and from a plat showing legislative grants along the Pacific coast, dated March 1960 (California State Lands Commission, State Lands Division, LRB 1573). None of the parcels or parcel boundaries shown or discussed in this section is to be considered or used for legal purposes of defining ownership. Public and private ownerships are shown for planning purposes only.

Upland Ownership

Plate 15 shows lands in public ownership in the study area (and for the Humboldt Hill area near the study area). The heavily urbanized areas of Eureka and Arcata (mostly outside the coastal zone boundary) were not mapped. The other lands in the study area are privately owned. Public owners include (a) local agencies such as Humboldt County, the Cities of Arcata and Eureka, College of the Redwoods, and the Humboldt Community Services District; (b) state agencies such as the Highway Department, the State Lands Commission, and the Humboldt State University; and (c) Federal Agencies (U.S. Fish and Wildlife Service, Bureau of Land Management).

Private land ownership is summarized below (area names refer to subareas shown in Plate 1, Geography).

Table Bluff. The area is generally held in parcels larger than 160 acres, some at 280-320 acres. Humboldt County has a county park and a landfill in this area.

South Spit. Much of the area is held by one owner, who additionally owns tidelands around the north end of the spit. The southernmost part of the spit is presently under option by the U.S. Fish and Wildlife Service to be part of the refuge (See Section VIII-A, Cultural Resources, 5. Refuges and Reserves). The State Lands Commission owns part of the spit. There is a considerable area of accreted land (sand beach) on the north end of the South Spit, ocean side; the accretion began after jetty construction in the 1890's.

Beatrice Park. Almost the entire area is held in 4 large ownerships. Two portions of the area have been subdivided; one is around Indianola and the other is east of the east branch of Hookton Slough.

FOR PLANNING PURPOSES ONLY
NOT FOR LEGAL USE





OWNERSHIP

PLATE NO 15 NORTH

LEGEND



Public Lands



Private Lands

Tidelands



Private



Leased from
Harbor District



Leased from
Eureka



Granted - Cities



Granted - Harbor
District (see text)

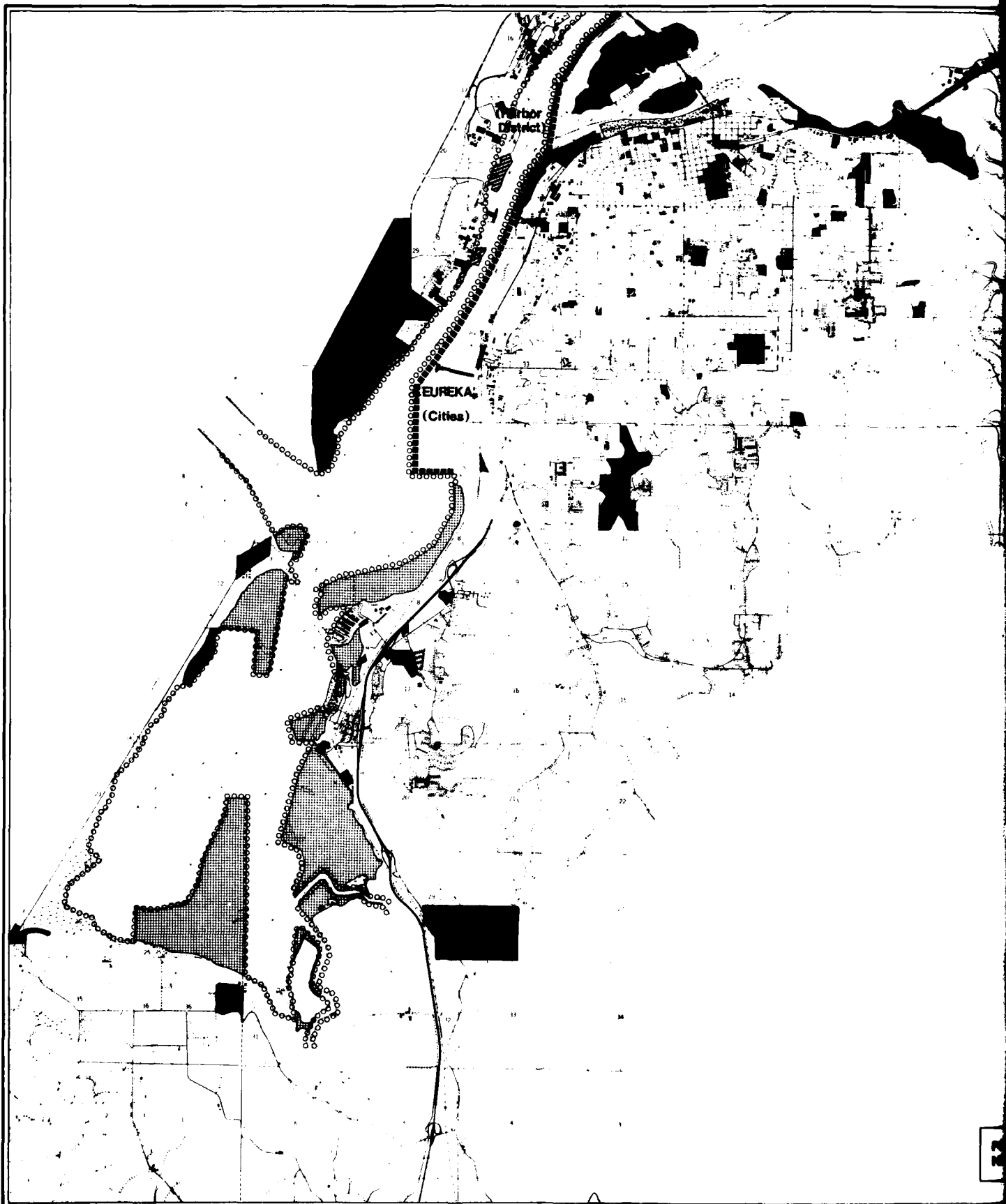


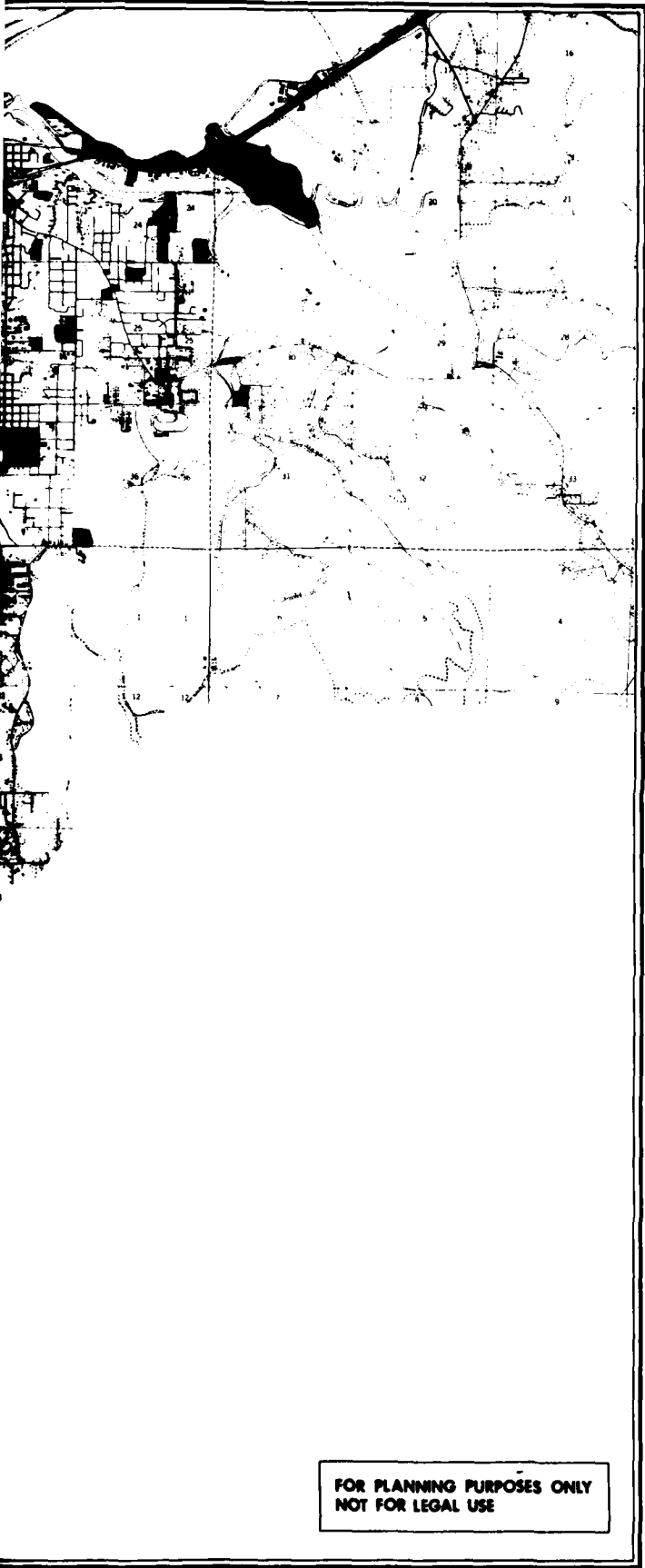
Litigation Areas (see text)



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: Humboldt County Assessors Office













OWNERSHIP

PLATE NO 15 SOUTH

LEGEND

-  Public Lands
-  Private Lands
- Tidelands**
 -  Private
 -  Leased from Harbor District
 -  Leased from Eureka
 -  Granted - Cities
 -  Granted - Harbor District (see text)
 -  Litigation Areas (see text)



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: Humboldt County Assessors Office

FOR PLANNING PURPOSES ONLY
NOT FOR LEGAL USE

1 2

Elk River. The bottom land of the Elk River and Martin Slough, and the adjacent uplands, are in 6-8 fairly large ownerships. The areas around King Salmon and Fields Landing are in smaller private parcels. There are two sewage oxidation ponds which are publicly owned and several other small parcels belonging to Humboldt County and the school district. The Elk River Spit is within the Eureka tidelands granted area (see Tidelands discussion below). The Spit began forming in the mid-1920's and had assumed approximately its present shape by about the mid 1940's. It is continuing to grow toward the north.

Eureka. The heavily urbanized area of the City of Eureka was only mapped in the portions west of Broadway and north of Highway 101. Much of the Broadway industrial area is in private ownership, with one owner controlling most of the portion west of Broadway from Bucksport to Murray Avenue, the City of Eureka, the Eureka Boat Basin and several other small parcels. Ownership of a large area of the Eureka waterfront is in question; the matter is presently in litigation. The litigation area is shown on Plate 15.

Islands. Indian Island is in public ownership, except for two small areas of the south shoreline which are privately owned. Both Woodley Island and Daby Island are shown on the assessor's records as privately owned. All of Woodley Island will be eventually owned by the Harbor District for the Woodley Island Marina and Habitat Area.

Eureka Slough. In the Eureka Slough area, there are fairly large private ownerships around Fay and Freshwater Sloughs. The more heavily developed uplands are in smaller parcels. Public lands include ownerships by the U.S. Fish and Wildlife Service, Eureka, and the school district.

Bayside Bottoms. The bottom lands in this area are mostly in 3 or 4 large ownerships. Public lands are owned by U.S. Fish and Wildlife Service, the school district, and the State. The area around the mouth of Jacoby Creek is an accreting area.

Arcata Bottoms. Ownerships in this area are mostly in holdings larger than 20 acres. Subdivided lands are located near James School and in the McKinleyville area. Public lands are owned by the City of Arcata, Humboldt County, Humboldt State University and the U.S. Bureau of Land Management. The Nature Conservancy owns a portion of the coastal sand dunes (See Section VIII-A, Cultural Resources, 5. Refuges and Reserves).

North Spit. Much of this area is held by mixed private industrial owners. The parcels are mostly larger than 20 acres except in the residential areas. The south end of the North Spit is in public ownership, partly City of Eureka and partly U.S. Coast Guard. There is a considerable area of accreted lands on the ocean side at the extreme south end of the Spit; the accretion began after jetty construction in the 1890's.

Tidelands Ownership

The Concept of Public Trust and Tidelands Grants. The following discussion of the public trust and tidelands grants is from A Report on the Use, Development, and Administration of Granted Tidelands and Submerged Lands, State Lands Commission, January 1976. Legal citations are as given in the Commission's report.

The State of California, in its sovereign capacity, possesses legal title to:

1. Tidelands, i.e., the area situated between the ocean's low and high water marks on the State's shoreline, including inlets or tributaries, covered by the daily flux and reflux of the tides;
2. Submerged lands lying: (a) beneath inland portions of the ocean and thence seaward three geographical miles from the coastline; and (b) in the beds of navigable streams and lakes.

During the 130 years since California's statehood, the State Legislature by statute, granted salt marsh, tide, and submerged lands whether filled or unfilled in trust to political subdivisions of the State principally for the general purposes of commerce, navigation and fisheries.

The concept of the "public trust", as applied to the State's tide and submerged lands, has evolved from the common and civil law and subsequent court interpretations of such law. It has played a major role in the administration of tide and submerged lands which have been granted "in trust" to local public jurisdictions by the State legislature.

According to Chief Justice Taney of the United States Supreme Court, "When the revolution took place, the people of each state became themselves sovereign; and in that character hold the absolute right to all their navigable waters, and the soils under them, for their own common use." (Martin v. Waddel, 16 Pet. (41 U.S.) 410, 10 L.Ed 997) Subsequent to the formation of the United States, each additional state was admitted into the union under the doctrine of "equal footing", that is, on a basis equal to that of the original thirteen states. It is through the application of this doctrine in 1845 (Pollard's Lessee v. Hagen, 3 How. 212, 230 (1845)) to the beds of navigable waters that the sovereignty over the tidelands (the lands lying between the lines of ordinary high and low tide) passed to California on September 9, 1850.

One of the earliest references to the "public trust" in California was in 1854 when the State Supreme Court said that the State: holds the complete sovereignty over her navigable bays and rivers and owns such lands for the purpose of preserving the public easement, or right of navigation (Eldridge v. Cowell, 4 Cal. 80, 87 (1854)).

This concept has been further defined as "a title held in trust for the people of the State that they may enjoy the navigation of the waters, carry on commerce over them, and have the liberty of fishing therein free from the destruction or interference of private parties..." (Illinois C. Ry. Co. v. Illinois, 146 U.S. 452).

In 1867, the Court established a precedent which pertains specifically to the State's administration of the tidelands within its jurisdiction and the responsibilities of those to whom the State grants such lands. Under this decision, "The right of the State is subservient to the public rights of navigation and fishery, and theoretically, at least, the State can make no disposition of them (the tidelands) prejudicial to the right of the public to use them for the purposes of navigation and fishery, and whatever disposition she makes of them her grantee takes them upon the same terms upon which she holds them, and, of course, subject to the public rights above mentioned " (emphasis and explanation added) (Ward v. Mulford, 32 Cal. 372 (1967).)

The State's power of disposition over the sovereign tide and submerged lands was further defined in 1897 when it was determined that, "No grants of lands covered by navigable waters can be made which will impair the power of a subsequent legislature to regulate the enjoyment of the public right. The trustee takes the mere proprietary interest in the soil, and holds it subject to the public easement" (Oakland v. Oakland W.F. Co., 118 Cal. 183 (1897)).

A modern statement of the evolving nature of the public trust doctrine is found in the case of Marks v. Whitney (6C. 3d 251).

"The public uses to which tidelands are subject are sufficiently flexible to encompass changing public needs. In administering the trust the state is not burdened with an outmoded classification favoring one mode of utilization over another.

There is a growing public recognition that one of the most important public uses of the tidelands--a use encompassed within the tidelands trust--is the preservation of those lands in their natural state, so that they may serve as

ecological units for scientific study, as open space, and as environments which provide food and habitat for birds and marine life, and which favorably affect the scenery and climate of the area. It is not necessary to here define precisely all the public uses which encumber tidelands."

California wasted little time in exercising its powers as a sovereign State with regard to her tidelands. Within seven months of Statehood, the Legislature granted lands in trust to the City of Martinez "...for the benefit of commerce, by the construction of wharves, piers and docks, and otherwise." Shortly thereafter, lands were granted to the City of San Francisco for the purpose of creating a permanent waterfront. Up to the early part of the twentieth century, the majority of legislative grants were within the geographical area in and around San Francisco Bay.

Historically, the objective of in-trust grants has been the development of the tide and submerged lands, with the State providing the geographic area and the trustee providing the planning, investment and physical developments. Early grants appear to have been made without specific terms, conditions or development guidelines of any kind. Enforcement of the provisions of the trust was largely affected during this early period by the courts through individual cases brought before them.

During the early 1920's, largely because development has not occurred in previously granted lands as anticipated, the Legislature began to impose more specific conditions on prospective trustees. Grants began to require a local jurisdiction to issue harbor improvement bonds, often in specified amounts. While the conditions of the grants gradually became more severe, the central purpose of such grants--development of tide and submerged lands--remained the same. Beginning in 1947 and continuing throughout subsequent years, the Legislature began to impose a duty upon local jurisdictions to improve the granted lands. Trustees were generally allowed 10 years in which to "substantially improve" lands under their administrative control.

The responsibility of determining whether granted tide and submerged lands had been "substantially improved" was given to the State Lands Commission. If the Commission finds that this condition of any grant has not been fulfilled, provision is made for the revocation of the trust provisions and reversion of the granted lands to the control of the State.

Tideland Grants in Humboldt Bay. The first tideland grant in the Humboldt Bay was made to the City of Eureka in Chapter 82 of the Statutes of 1857; this legislation is reprinted below in its entirety:

CHAPTER LXXXII. (82)

AN ACT

To cede certain Property to the Town of Eureka

[Approved March 13, 1857.]

The People of the State of California, represented in Senate and Assembly, do enact as follows:

SECTION 1. The State of California hereby cedes and grants to the town of Eureka, in the County of Humboldt, the entire water front of said town within the corporate limits thereof; and also, all the right, title and interest of the said State, in and to, all the lands within the corporate limits of said town.

SEC. 2. The board of Trustees of said town, are hereby authorized and required to lay off the said water front, in lots of such size, and in such manner, as will accommodate and subserve the interest of the present "mill-owners," and other occupants, and shall proceed to sell such lots as are now in the bona fide possession of such "mill-owners" and other occupants, to said occupants at a price not to exceed one dollar per front foot, and extending from high water mark to a point in the bay, where the water shall not be over six feet deep, at low tide. Provided, That unless the occupants, (within six months after said lots shall be offered for sale,) shall purchase and pay for the same, the Board of Trustees shall, after twenty days notice, offer the same for sale at public auction, and sell to the highest bidder for cash.

SEC. 3. The entire net proceeds of such sale shall be paid over to the Town Treasurer, for the benefit of the town.

The waterfront and tide and submerged lands were sold to private parties. From this 1857 legislation, boundary and ownership problems have resulted and are only now being resolved. Several areas, including part of the Eureka waterfront, the Fields Landing waterfront between the Kramer Dock and Olson Terminals, and the Louisiana Pacific (LP) waterfront from the Highway 255 bridge to south of the LP power plant, are still under litigation (Plate 15).

In 1909, the State of California instituted a constitutional prohibition against the sale of tidelands to private parties (Rusconi,

personal communication, 1979). Since then the granted tidelands have been leased for private uses, but not sold outright.

Additional tidelands were granted to the City of Eureka by the following legislation: Ch. 438, Stat. 1915; Ch. 187, Stat. of 1927; Ch. 225, Stat. of 1945; and Ch. 1086, Stat. of 1970. These grants were much more specific than the 1857 grant, both in granted area and in purpose. The tidelands granted by the cited statutes are shown on Plate 15. The City of Eureka is authorized to use the granted lands, and tide and submerged land trust revenues, for the establishment, improvement, and conduct of a harbor and other utilities, structures, and appliances for promotion and accommodation of commerce and navigation. The City is authorized to use the trust revenues, but not the lands themselves for the following purposes: Air commerce and navigation facilities and airports; highways and parking facilities; public buildings and recreation facilities; small boat harbors and marinas; commercial and industrial uses; for wildlife habitat and aesthetic purposes; and for promotion of public use and activities of statewide interest.

Chapter 1555, Statutes of 1970, adding Section 6374 to the Public Resources Code, required any trustee of granted lands to submit a report on the use and development of such lands, together with a general plan for future use, to the State Lands Commission. In Eureka's report, the City expressed the wish to do the following: Increase access corridors to granted lands, redevelop wharf and warehouses; develop Eureka fish dock for docking visiting ships, permitting educational marine research; retain the Elk River Sandspit as a unique environmental feature suitable for preservation and scientific study; encourage multipurpose commercial development, provision for tourist use, with maintenance of other areas in their natural state. Chapter 1252, Statutes of 1971 and Chapter 1095, Statutes of 1978 amended and added to Ch. 1086, Stat. of 1970 (granting tidelands to Eureka) as follows: The Humboldt Bay Fund, with appropriations from state oil and gas revenues and from Eureka tideland revenues, was established to allow the city to continue the administration of its trust in the best public interest and to assist the city in its waterfront and tideland litigation expenses (the litigation to clear and confirm titles to waterfront properties was declared to be in the best interests of the state).

Tidelands granted to the City of Arcata are also shown on Plate 15; the grants were made in Ch. 344, Stat. of 1913 and Ch. 542, Stat. of 1917. Under this legislation, Arcata is authorized to use the granted lands and the trust revenues for the establishment, conduct, and improvement of a harbor and other facilities for commerce and navigation. Planned uses of granted lands noted in Arcata's report to the State Lands Commission, 1976, included extensive bay fill for industrial development south of Samoa Road (1966 Arcata General Plan) and ocean beach, sand dunes, back dune, woodland, and the Mad River Slough as a regional preserve (Interim Report on Conservation and Open Space, 1972). The State Lands Commission has

accepted construction of Arcata's Marsh Enhancement Project (see Section VIII.A.3, Recreation, and Plate 22) as a suitable use of granted land.

All of the tide and submerged lands in the study area which were not privately owned or granted to Eureka or Arcata were State-owned until they were granted to the Humboldt Bay Harbor, Recreation, and Conservation District (Harbor District). The creation of the Harbor District was authorized by the legislature in Ch. 1283, Stat. of 1970 and the District was then created by the voters in 1973. Chapter 1191, Stat. of 1974, amended Ch. 1283 (1970) and officially granted the tidelands to the Harbor District. Any tide and submerged lands in the study area outside those of Arcata and Eureka are held in trust by the Harbor District. All tideland or submerged land leases, permits, and agreements held by the State were also transferred to the Harbor District by Ch. 1191, Stat. of 1974. The Harbor District's grant allows the granted lands, and trust revenues, to be used for the following purposes: a harbor and facilities for commerce and navigation; airports; highways, public buildings and public recreation facilities; small boat harbors and marinas; commercial and industrial uses; uses in the public and statewide interest; and wildlife habitats.

Privately-Owned and Leased Tidelands

Privately-owned and leased tidelands in the study area (as identified from assessor's records) are shown on Plate 15. Substantial portions of North, Middle and South Bays are privately owned tide and submerged lands. In addition, a large part of North Bay (both Harbor District and Eureka tidelands) is leased for commercial oyster culture. There are small leased areas in Middle Bay near the channel. Representatives of Pigeon Point Shell Fish Hatchery indicate that the company has leases on the Mad River Slough tide and submerged lands from Lanphere Road to Samoa Boulevard.

Concern over the rights of public use and access to tide and submerged lands (public trust) is demonstrated by Ch. 1742, Stat. of 1971, amending Section 6008 of the Public Resources Code. This legislation prohibits any sale, lease, rental, or other conveyance or grant of the right to use submerged lands in and adjacent to Humboldt Bay south of the bay entrance. (Rights in such lands existing before 1 October 1961 were not affected by Ch. 1742.)

C. GOVERNMENTAL PROFILE

This section discusses the plans and policies of the various governmental interests that interact with the Corps of Engineers during the permit process and/or that have planning or construction interests in the study area. Some of these governmental entities are specific to the Humboldt Bay study area; others, including Federal and state agencies, have review responsibility for Corps permit applications throughout the San Francisco District.

Section IV, THE PERMIT PROCESS, describes the review process for each Corps permit application. That section identifies the points at which public and agency review is initiated and the points at which decisions on permit issuance are made. A summary of Federal, state and local agencies, public groups, private industry, and individuals to whom Corps permit applications are normally sent for review and comment is also included.

Corps permit regulations (33 CFR 320-329) require an evaluation of the extent to which a proposed permit activity is in the public interest. This is the most important criterion applied in the decision to issue a permit. For any permit application the Corps must consider all applicable official state, regional, or local land use plans and/or policies as reflecting local factors of the public interest (33 CFR 320.4(j)(2)); thus, the Corps will request review of permit applications in the study area by local governments. In addition, the Corps is required by permit regulations to coordinate and consult with certain Federal and state agencies (33 CFR 320.4) so that permit decisions will reflect factors of the national and statewide public interest. In addition to permit review, Federal, state, and local agencies have plans or projects in the study area which may be of interest to the Corps. In the Humboldt Bay study area, plans, policies, and proposed activities are of mutual interest to the Corps and the following principal federal agencies:

1. U.S. Department of the Interior (DOI)

Fish and Wildlife Service
Bureau of Land Management
National Park Service
Heritage, Conservation, and Recreation Service

2. U.S. Department of Commerce (DOC)

Office of Coastal Zone Management
National Oceanic and Atmospheric Administration/
National Marine Fisheries Service/National Ocean
Survey
Economic Development Administration

3. U.S. Environmental Protection Agency (EPA)

4. U.S. Department of Transportation

U.S. Coast Guard
Federal Highway Administration

5. Advisory Council on Historic Preservation

6. U.S. Department of Agriculture (USDA)

Soil Conservation Service
Agricultural Stabilization and Conservation Service

7. U.S. Council on Environmental Quality

In addition, the following principal state and local agencies are interested in Corps plans, policies, and permit activities in the Humboldt Bay study area.

1. California State Agencies

The Resources Agency
Department of Conservation
Department of Fish and Game
Department of Forestry
Department of Boating and Waterways
Department of Parks and Recreation
Department of Water Resources
California Coastal Commission, North Coast Region
Coastal Conservancy
Energy Resources Conservation and Development
Commission
State Lands Commission
Air Resources Board
State Water Resources Control Board
Department of Transportation
Office of Planning and Research
State Historic Preservation Office
Department of Health

2. Humboldt County Council of Governments

3. Local Government

Humboldt County
City of Arcata
City of Eureka
Zoning

4. Local Special Agencies and Districts

Humboldt Bay Harbor, Recreation, and Conservation
District

North Humboldt Park and Recreation District
Humboldt Bay Wastewater Authority
Redwood Region Economic Development Commission
Humboldt County Local Agency Formation Commission
Humboldt County Air Pollution Control District
Other Special Purpose Districts (community service,
water, sewer, fire, etc.)

Besides the above, there are other agencies, public and private organizations, and individuals who receive notification of and may comment on permit applications. The agencies listed above represent the governmental entities with the most specific interest in the Humboldt Bay study area.

For this study, the most important plans and policies of these agencies are as follows:

- . Special policies relating to wetlands or habitat preservation in general or in particular parts of the study area.
- . Special policies on Corps permit activities.
- . Special concerns of the particular agency which may be affected by a Corps permit activity (e.g., fish and wildlife habitat is a particular concern of USFWS and the State Department of Fish and Game.

These will be noted and documented to agency regulations or programs wherever possible.

FEDERAL AGENCIES

U.S. Fish and Wildlife Service (DOI, FWS)

The U.S. Fish and Wildlife Service is responsible for the federal interest in conservation, enhancement, and protection of fish and wildlife habitat and resources. Under the Fish and Wildlife Coordination Act (16 USC 661-666c), any federal agency proposing to modify or control any body of water must first consult with FWS; thus, this Act provides the basic authority under which FWS reviews Corps permit applications. In the Corps permit review process, FWS must be consulted in the evaluation of the possible effects of the permit activity on fish and wildlife resources. FWS has guidelines for the review of fish and wildlife aspects of proposals in or affecting navigable waters (40 FR 55810-55824; 1 December 1975); these guidelines contain the criteria used in review of Corps permits.

One important criterion used by FWS is water dependency; if an activity is non-water dependent, particularly where biologically productive wetlands are involved, and upland sites are available, FWS may recommend denial of the permit unless the public interest requires otherwise. Even for water dependent uses, FWS discourages the use of biologically productive wetlands and shallows (p. 55813). Wetlands, estuarine habitats, and certain species are of particular concern to FWS. Public interest is another important criterion; it may be indicated by an approved land use plan or by weighing all factors as described in 33 CFR 320.4(a). All proposals are evaluated for adverse environmental effects, need, benefits, water dependency, long-time and cumulative effects, and possible mitigating measures. In general, any encroachment which would significantly damage biologically productive shallows and wetlands or unreasonably infringe on public rights of access, use, and enjoyment will be discouraged by FWS.

The FWS has developed a nationwide habitat evaluation system to determine habitat value based on benefits received by fish and wildlife (FWS, Division of Ecological Services, 1976). In this system, a "habitat type unit value" is determined by rating the capability of the habitat to meet the requirements of a given variety of animals. The procedure is highly dependent on the species chosen for consideration of requirements. The FWS is directed to use this habitat evaluation system whenever possible in determining fish and wildlife losses from proposed projects and in calculating the amount of compensation necessary to replace such losses. The Corps of Engineers does not use the FWS habitat evaluation procedures.

The FWS also has specific policies for review of Corps permit activities including docks and piers, moorage, platform structures, marinas and port facilities, bulkheads and seawalls, cables, pipelines, transmission lines, bridges and causeways, jetties, groins, breakwaters, lagoons, navigation channels, drainage ditches, dredging and filling, mineral exploration, log handling and storage, and facilities needing cooling waters. The FWS has specific guidelines for coordination with the Corps and other governmental agencies (40 FR 55820).

The FWS has several specific concerns in the Humboldt Bay study area. The agency has approval to acquire acreage for and manage the Humboldt Bay National Wildlife Refuge (See Section VIII.A, Cultural Resources, 5. Refuges and Reserves). A review of FWS responses on permit applications in the study area shows that a major concern of the agency is compensation for loss of valuable habitat, in particular fresh and salt marsh. Compensation generally means off-site restoration of former tide lands to full tidal action and/or the creation of off-site habitat similar to that which will be

lost with the proposed project. In the case of the proposed Woodley Island Marina, the FWS had a specific permit evaluation prepared by a consultant (EDAW, Inc., 1978). In this report, the characteristic habitat types, sensitivity levels, and quality objectives of Humboldt Bay were evaluated, and the proposed project considered in this context.

The FWS is conducting the National Wetlands Inventory, classifying and mapping wetlands across the nation; Humboldt Bay area mapping under this program was carried out in 1978-1979. (See Section III.B, Volume III, for a discussion of FWS and Corps wetland definitions.) The agency administers various other laws and programs, including the Endangered Species Act.

Bureau of Land Management (DOI, BLM)

The Bureau of Land Management, under a multiple-use philosophy, carries out a variety of resource management and development activities on federal lands. Fish and wildlife management, livestock grazing, outdoor recreation, timber protection, wilderness preservation, real estate, and mineral activities are all carried out on national resource lands. BLM must prepare Habitat Management Plans for the public lands to protect, maintain, and enhance wildlife habitat.

In the study area, the BLM controls acreage along the ocean beaches near the north end of the North Spit. More important, however, is the BLM's role as the administrative agency in charge of leasing submerged lands for mineral exploration and development of the Outer Continental Shelf (OCS). The U.S. Geological Survey is the agency responsible for supervising production from these lands.

In 1953 the OCS Lands Act (67 Stat. 462) was passed, extending Federal jurisdiction to the submerged lands of the continental shelf seaward of state boundaries (3-mile limit). Under the National Environmental Policy Act of 1969 (NEPA) extensive environmental studies of OCS lands became necessary. The BLM has conducted a number of environmental studies of the Northern California OCS and coastal environments, including a literature survey of available knowledge (Winzler and Kelly, 1977) and a study of geologic hazards (USGS, to be available in 1979).

On 10 October 1978, the Department of Interior announced the selection of 243 tracts comprising 1.3 million acres offshore Central and Northern California for intensive environmental study in a sale of OCS oil and gas leases proposed for February 1981 (OCS #53). Part of the selected tracts lie in the Eel River Basin offshore from the Humboldt Bay study area. The BLM has developed an OCS Environmental Studies Plan for central and northern California

relative to OCS #53 which details some of the environmental concerns. Major concerns include effects of OCS development on commercial fishing, shipping, recreation, marine and coastal ecological relationships, social and infrastructure stress, air and water quality, and archaeological and historical resources (BLM, 1978). The Plan identified the Eureka/Humboldt Bay area as having a wildlife refuge, an important offshore trawl fishery, and problems with air quality. The Pacific OCS office, BLM, will be developing five detailed environmental studies for Central and Northern California in FY 1979; these include a summary of available physical oceanographic and meteorological data, a marine mammal and seabird survey, an ecological characterization of the coastal region, an air quality modeling study for Sale #53 development scenarios, and a study of geohazards for the Sale #53 area (Keene, 1979, personal communication). BLM will also fund two national studies on issues germane to the California coastal region; these will examine conflicts of OCS activities with the fishing industry and effects of OCS activities on marine mammals (Keene, 1979, personal communication). An environmental studies plan for FY 1980 will be available in June 1979. A draft environmental impact statement on Lease Sale #53 are projected for spring 1980.

National Park Service (DOI, NPS)

The National Park Service administers national parks and recreation areas. None of these exist in the study area; however, the Redwoods National Park is both north and south of Humboldt Bay, and its recent expansion was a source of major concern among study area citizens. It is felt that the expansion will cause serious adverse effects on the lumber and wood products industry, the most important sector of the Humboldt Bay economy (See Section VIII-C, Economic Profile).

Heritage, Conservation, and Recreation Service (DOI, HCRS)

The Heritage, Conservation, and Recreation Service (HCRS) is an agency formed in 1978; it has assumed all the functions of the Bureau of Outdoor Recreation and the Natural Landmarks Program and Historic Register functions of the National Parks Service and Office of Archaeology and Historic Preservation. The HCRS thus participates directly in the planning and coordination of policies relating to recreation and fish and wildlife benefits (a former Bureau of Outdoor Recreation function) and administers the National Register of Historic Places. This latter function overlaps that of the Advisory Council on Historic Preservation. HCRS acts as a contracting agent for federal projects. It prepares scopes of work for federal projects and acts as a quality control for historical parts of federal projects. HCRS reviews projects proposed by other agencies for historical and recreational aspects (Bass, 1979, personal communication).

Under the DOI, historic site surveys and interagency archaeological services are carried out.

Office of Coastal Zone Management (DOC, OCZM)

Under the Coastal Zone Management Act, OCZM provides federal grants for development of coastal management and preservation programs, including planning for the impacts of offshore energy development in coastal states. OCZM also authorizes designation of marine areas as sanctuaries to preserve, restore, or enhance conservation, recreation, ecological or aesthetic values of these water resources.

National Marine Fisheries Service (DOC, NMFS)

The National Marine Fisheries Service is part of the National Oceanic and Atmospheric Administration (NOAA). NMFS is the federal agency administering programs for development and preservation of marine fish and wildlife resources, including estuarine and anadromous fish. Like FWS, NMFS reviews all Corps permit applications under the basic authority of the Fish and Wildlife Coordination Act and Reorganization Plan No. 4 of 1970, which transferred responsibility for certain fish and wildlife-water resources coordination from DOI to DOC. The agency has an environmental assessment program; the objective of which is to conserve, protect, and enhance the marine, estuarine, and anadromous habitats of living marine resources (Living Coastal Resources, p. 28; this is a document summarizing the regulations of FWS and NMFS; it was published by NOAA and FWS in July 1976). Corps permit applications are reviewed under this program to analyze impacts on these habitats. NOAA (NMFS) has regulations dealing with federal grants under sections 305 and 306 of the Coastal Zone Management Act (15 CRS 920 and 15 CFR 923); under these regulations "areas of particular concern" are designated. These areas have characteristics such as unique, scarce, or vulnerable habitat, high natural productivity, substantial recreational value, unique geology or topography, significant physical hazard potential, or value as protection for coastal resources (aquifer recharge, etc.). Permit applications in such areas will be particularly scrutinized by NMFS. Under the Endangered Species Act of 1973 (16 USC 1531-1543) NMFS (and FWS) may designate critical habitats and coordinate federal agency activity to prevent modification of these habitats. NMFS has not designated any areas of particular concern or critical habitats in the study area.

Under the Fishery Conservation and Management Act of 1976 (PL 94-265), NMFS conducts biological fisheries research on impacts of pollution and degradation of wetlands. The objective of the Act is to manage fishery resources. NMFS is the Federal coordinator for the Pacific Fisheries Management Council (PFMC), charged with the

development of management policies for federal fisheries off the coast (see Section VIII-C, Economic Profile, Fisheries). Management policies of the PFMC affecting the study area are aimed at reducing the size of the fishing fleet and limiting entry of additional fishing units (Ayers, 1979, personal communication).

National Ocean Survey (DOC, NOS)

The NOS, formerly the U.S. Coast and Geodetic Survey, is part of NOAA. NOS is responsible for coastal surveying, preparation and maintenance of navigation charts, and measurement of tidal datums. The NOS has at present eight stations measuring tidal datums in Humboldt Bay, shown in Table VI-4, Section VI.G, Tidal Characteristics (NOAA, 1979).

Economic Development Administration (DOC, EDA)

The EDA is a granting agency and provides funds for economic development in certain areas. Criteria for providing funds to an area include a history of chronic unemployment, a low average per capita income measured against other benchmark economies and special actions by the federal government which may have negative economic impacts on a local economy (Land, 1979, personal communication). The Humboldt Bay study area meets all these criteria. Humboldt County was given a Title IX grant by EDA in September 1977 to prepare an economic action development plan to mitigate expected impacts of the proposed expansion of the Redwood National Park (QRC Corporation, 1978). The EDA also provides funds for specific projects such as the Woodley Island Marina.

U.S. Environmental Protection Agency (EPA)

The Humboldt Bay study area is in Region IX of the Environmental Protection Agency. EPA is responsible for the administration of the Federal Water Pollution Control Act (PL 92-500) and its Amendments (FWPCA). Under Title III of PL 92-500, water quality standards and effluent limitations are established. Discharges into navigable waters are regulated under Title IV of this act. In general, EPA will evaluate all Corps permit applications to determine the possible impacts on water quality (and air quality, toxic substances, and radiation).

Under Section 404 of FWPCA,* the authority for issuance of permits for discharges or dredged or fill material into navigable waters is given to the Corps, but the disposal sites must meet EPA criteria. Under EPA guidelines for discharge of dredged and fill material pursuant to Section 404 (40 CFR 230) EPA can deny or re-

*FWPCA is now referred to as the Clean Water Act (CWA).

strict the use of any area as a disposal site if such use would have an unacceptable adverse effect on municipal water supplies, shellfish beds, fishery areas (including spawning and breeding), wildlife, recreational areas, endangered species, benthic life, or wetlands. Criteria for wetlands of importance under 40 CFR 230 are very similar to those in Corps permit regulations (33 CFR 320-329). Submerged vegetation and the size of the disposal site are to be considered. The need for the proposed discharge, alternative sites, and water quality standards must also be considered. In addition to 40 CFR 230, EPA has a policy statement on Protection of the Nations' Wetlands, designed to protect wetlands from the adverse effects of dredge and fill operations and solid waste management. Corps permit applications will be reviewed by EPA for consistency with this policy.

Under Section 403, FWPCA, PL92-532 (The Marine Protection, Research, and Sanctuaries Act of 1972), and 40 CFR 220-229, EPA promulgated guidelines for the granting of permits for ocean dumping; the Corps may issue permits for transport of dredge material for ocean dumping under Part 225 of 40 CFR 220-229 if the application meets the established EPA criteria.

EPA is responsible for federal-level management and control of non-point source pollution under Section 208, FWPCA; in the study area, non-point source pollution is principally from agricultural and from urban runoff and septic tank systems.

EPA also issues permits for the discharge of pollutants (e.g. sewage outfalls) to aquaculture projects. Such discharges are evaluated as to their value as food sources for aquatic organisms (40 CFR 115).

The EPA is responsible for the administration of the Clean Air Act, which was significantly amended in 1977. Under this act, the agency promulgates national air quality standards and performance and emission standards for stationary and moving (vehicular) sources. Section 107 of the Clean Air Act (1977) requires that all areas of California be designated as to their status of attainment of national ambient air quality standards (NAAQS). Areas designated as "non-attainment" must submit SIP revisions to EPA in early 1979 which demonstrate attainment of NAAQS by 1982. Humboldt County has been designated a nonattainment area for particulates. Section 172 of the Clean Air Act (1977) defines nonattainment plan requirements.

Areas not classified as nonattainment are subject to requirements for the prevention of significant deterioration as described in Part C of Title 1 of the 1977 Clean Air Act Amendments. The EPA has promulgated regulations (40 CFR, Section 52.21) requiring states to provide for prevention of significant deterioration (PSD) for total suspended particulates and sulfur dioxide. The regulations identify three possible categories for clean air areas (Class 1, very little deterioration; Class 2, moderate deteriora-

tion; Class 3, up to secondary standards), each reflecting different social, economic, and environmental needs. In addition to requirements for no significant deterioration, EPA also requires (40 CFR, Section 51.12) that the states provide for continuous acquisition of data used to evaluate future air quality in all parts of the states.

Proposed Corps permit applications are also reviewed by EPA under their guidelines for the implementation of NEPA (40 CFR Part 6). Activities are examined for specific impacts on the physico-chemical and biological environment and for secondary impacts, such as induced growth.

U.S. Coast Guard (DOT)

The U.S. Coast Guard regulates vessel traffic for safety in navigable waters and is responsible for navigation aids and for permits for bridges over navigable waters. Under 33 CFR 126, the Coast Guard issues permits for handling of explosive or other dangerous cargo at waterfront facilities designated as suitable for such cargo. Under 33 CFR 154-156, and in accord with Section 311(j)(1)(c), FWPCA the Coast Guard controls and supervises oil transfers and promulgates equipment and vessel design specifications to prevent oil spills. In the Humboldt Bay study area the Coast Guard has a station on the south end of the North Spit, and the Coast Guard Cutter dock is located at Fields Landing.

Federal Highway Administration (DOT, FHWA)

The FHWA both builds Federal highway projects and provides Federal funds to State and local governments for highway construction and improvements. As a federal agency, the FHWA must be responsive to wetlands protection policies of the Federal government, such as Executive Order (EO) 11990: Protection of Wetlands.* The FHWA has issued Interim Guidance and Procedures (FHWA, October, 1977) for compliance with Section (2) of EO 11990; these procedures define terms and projects covered by EO 11990 and require public involvement in plans for projects located in wetlands. FHWA is also required to prepare findings on practicable alternatives and mitigating measures.

*Executive Order 11990, discussed in detail in Section IB of the complete report, mandates federal agencies (1) to preserve and enhance wetlands values and minimize wetland degradation in managing federal lands and facilities, providing federally financed construction and conducting federal land use programs, and (2) to avoid undertaking or providing assistance for new construction in wetlands unless (a) there is no practicable alternative, and (b) the proposed action includes all practicable measures to minimize harm to wetlands.

In the Humboldt Bay study area, the FHWA has prepared wetland protection findings on the proposed construction of a new bridge spanning Mad River Slough and reconstruction of Young Lane approaching the bridge. The report concluded that about 2½ acres of right-of-way would be required, about 1 acre of which was salt marsh and 0.3 acres reclaimed agricultural pastureland. The California Department of Fish and Game required replacement of two acres of marsh to mitigate the loss of one acre taken by the proposed project. FHWA proposed to acquire a 17-acre parcel adjacent to the Elk River and Route 101 south of Eureka, on which tide gates could be removed to allow tidal waters to inundate portions of the property.

Advisory Council on Historic Preservation

The Advisory Council on Historic Preservation reviews proposed activities for effects on historic sites. The department heads interagency coordination on the federal level to consider sites nominated for the National Register. It may hold public meetings on specific proposals and conduct field inventories of historic data. The Advisory Council promulgates guidelines for consideration of National Register eligibility.

U.S. Department of Agriculture (USDA)

The USDA, under the Water Bank Act of 1970 and the Agriculture and Consumer Protection Act, administers programs to preserve wetlands important for breeding and nesting of migratory waterfowl and to increase and improve fish, wildlife and recreation resources.

The Agricultural Stabilization and Conservation Service (ASCS) has resource conservation programs for preventing loss of wetlands and preserving, restoring, and improving water areas. The ASCS provides funds to farmers for activities such as pasture fertilization and seeding and for construction of ponds. The Agricultural Extension Service supplies educational programs, bulletins, and expert information to aid farmers in horticulture, farm management, and marketing technique. The Soil Conservation Service (SCS) is principally concerned with conservation of soils and water resources. The SCS has classified soils according to their suitability for agricultural use and provides guidelines and recommendations for other uses of the various soil types (see Section VI-E, Agricultural Soils). The SCS has water resource conservation and development programs and will provide site-specific advice on soil conservation. SCS Conservation Planning Memorandum 15 contains a policy statement that wetlands should be preserved, restored, and/or improved wherever possible.

U.S. Council on Environmental Quality (CEQ)

The CEQ administers the National Environmental Policy Act (NEPA) and promulgates guidelines for use in preparation of environmental impact statements on federally-sponsored or federally-funded projects. The final regulations for implementing NEPA were published by CEQ on 29 November 1978 (FR 43, 230) to be effective 30 July 1979.

CALIFORNIA STATE AGENCIES

The Resources Agency; Office of the Secretary for Resources

The Secretary for Resources, a member of the Governor's Cabinet, has general supervisory power over the operations of six departments, 24 boards and commissions, and several related advisory committees and commissions in the state. In the Humboldt Bay study area, the Resources Agency departments and commissions with interest and/or jurisdiction include: The Departments of Conservation, Fish and Game, Forestry, Boating and Waterways, Parks and Recreation, and Water Resources, with all their commissions and committees; the California Coastal Commission; the Coastal Conservancy; the Energy Resources Conservation and Development Commission; the State Lands Commission; the Air Resources Board*; the Solid Waste Management Board*; and the State Water Resources Control Board. The Secretary assists and advises the Governor in the formulation of major policies and programs on the management and conservation of natural resources in the State. The agency has been given the responsibility of developing a State position on all federal activities; in this capacity, the agency coordinates all permit and project reviews (Goodson, 1979, personal communication). The Secretary is responsible for resolving conflicts among and coordinating the activities of the various units in the Resources Agency.

The Resources Agency has developed policies for wetlands protection (Resources Agency, 1977) and shoreline erosion protection (Resources Agency, 1978) which are of particular interest for this study. The wetlands policy recognizes the value of wetlands to the economy and to the overall quality of life. The policy is as follows:

BASIC WETLANDS PROTECTION POLICY

It is the basic policy of the Resources Agency that this Agency and its Departments, Boards and Commissions will not authorize or approve projects that fill or otherwise harm or destroy coastal, estuarine, or inland wetlands.

*These Boards report through a Special Assistant to the Governor for Environmental Protection.

Exceptions to this policy may be granted provided that the following conditions are met.

1. The proposed project must be water dependent or an essential transportation, water conveyance or utility project.
2. There must be no feasible, less environmentally damaging alternative location for the type of project being considered.
3. The public trust must not be adversely affected.
4. Adequate compensation for project-caused losses shall be a part of the project. Compensation, to be considered adequate, must meet the following criteria:
 - a. The compensation measures must be in writing in the form of either conditions on a permit or an agreement signed by the applicant and the Department of Fish and Game or the Resources Agency.
 - b. The combined long-term "wetlands habitat value" of the lands involved (including project and mitigation lands) must not be less after project completion than the combined "wetlands habitat value" that exists under pre-project conditions.

In the wetlands policy, water-dependent is interpreted as physically dependent on the water; projects such as restaurants or shopping malls which may benefit economically from a shoreline or over-water location are not considered water dependent (Goodson, 1979, personal communication). Wetlands under this policy are considered to be areas with wetland values for wildlife; this is a very general definition and allows a broad interpretation of what constitutes a wetland (Goodson, 1979, personal communication). Exceptions to the wetlands policy have been made for already existing projects (Goodson, 1979, personal communication).

The policy for shoreline erosion protection is to be used by State agencies when reviewing proposed permits, projects, and plans, and when planning state projects. The thrust of the policy is to emphasize sand replenishment (beach nourishment) as an alternative to construction such as breakwaters, groins, and seawalls. In fact, the policy significantly discourages artificial structures to control coastal erosion. It provides for use of dredged material for beach nourishment for development and runoff measures to control erosion, and for State financial participation in shoreline erosion protection projects; for state financial participation, non-structural measures should be used wherever feasible.

Department of Conservation

The Department of Conservation is comprised of the Division of Mines and Geology, the Division of Oil and Gas, the Geothermal Resource Board, and the State Resource Conservation Commission. (This commission is no longer budgeted (Leaf, 1979, personal communication).) The Department has responsibility for the utilization and conservation of soil resources, regulation and development of the oil and geothermal resources of the State (within the three mile limit) and protecting the reclamation of mined lands. It also has responsibility for the seismic and geologic safety of lands in California.

The Department promotes the preservation of prime agricultural land through the Open Space Subvention Program. Under the California Land Conservation Act of 1965 (Williamson Act), Class I and II soils (defined by USDA) may be designated as agricultural preserves (100 acre minimum). Landowners within the preserve may contract for 10 to 20 years with local government to accept open space restrictions in return for current use tax assessment. The Open Space Subvention Program, passed by the legislature in 1971, reimburses cities and counties for tax revenue losses resulting from reduced assessments of lands restricted to agricultural and open space uses under the Williamson Act and other open space legislation. As of 1977, there were no preserves under the Williamson Act in the Humboldt Bay study area (Leaf, 1979, personal communication).

Department of Fish and Game (DFG)

The Department is responsible for the protection and management of fish and wildlife in California. The following units work with and make recommendations to the Department:

1. The Fish and Game Commission. Encourages the conservation and maintenance of wildlife resources by maintaining sufficient populations of all species of wildlife and the habitat, perpetuates all species for their intrinsic and ecological values, provides for recreational and commercial uses of wildlife, and regulates taking or possession of wildlife.
2. The Marine Research Committee. Researches the development of commercial fisheries of the Pacific Ocean and of marine products potentially available to California.
3. The Wildlife Conservation Board. Determines essential wildlife protection areas in the State and classifies

lands for their suitability as game refuges, bird refuges, fish hatcheries, and hunting areas. It authorizes acquisition of lands, rights in land, water, or water rights, and construction on such holdings (Wildlife Conservation Law of 1947 and others).

4. Pacific Marine Commission. Organized for the purpose of allowing the State to have some mechanism to work together for the betterment of the marine fishery resources that are jointly used by California, Oregon, Washington, Idaho, and Alaska.
5. The Pacific Fisheries Management Council. Formulates management plans for the fisheries within the 200 mile limit (See NMFS above and Section VIIIC, Economics, Fisheries).

The regulations of the Department of Fish and Game are in The Fish and Game Code (DFG, 1975 and 1976; Lollock, 1979, personal communication). DFG has regulatory authority over harvest of fish and game and the taking of wildlife; it also issues stream alteration agreements for any activity which will alter the natural state of any river, stream, or lake. The Fish and Game Code has several sections specific or relative to the Humboldt Bay study area, summarized below:

1600-1604. Fish and Wildlife Protection and Conservation. Stream alteration agreement necessary for any project which would change the flow, channel, bed, or banks of rivers, streams, and lakes having wildlife resource value.

3511. Fully protected birds which may not be taken at any time: (a) occurs in study area - American peregrine falcon, Brown pelican, California least term, White-tailed kite; (b) Doubtful in study area - Clapper rails (California and light-footed), Greater sandhill crane, Golden eagle, Southern bald eagle; (c) Not observed in study area - California black rail, California condor, Trumpeter swan, Yuma clapper rail (Yocum and Harris, 1975; Monroe, 1973).

4700. Fully protected mammals: of those listed, only the ring-tailed cat is found in the Humboldt Bay area (Monroe, 1973).

5515. Fully protected fish: Possibly in study area - Unarmored threespine stickleback and Rough sculpin (Monroe, 1973).

6503. Prevention of sale, lease, or granting of tide or submerged lands in South Humboldt Bay to protect public access and use rights.

6512,6483. Oyster and marine life preserves. There are oyster and clam reserves in Humboldt Bay; See Section VIII-A, Cultural Resources, 5. Refuges and Reserves.

8183. Prohibition of anchovy harvest in Humboldt Bay; an urgency statute. This prohibition has been lifted; See Section VIII-C, Economic Profile, Fisheries.

11014-11017. Fish and Game District boundaries: Humboldt Bay itself constitutes Districts 8 and 9; the ocean waters from Humboldt Bay entrance north to the state line are District 6, while the ocean waters south to the southern boundary of Mendocino County are District 7.

Chapter 2, 8140-8535. Seasonal taking of fish in the various districts. Specific restrictions for Humboldt Bay (Districts 8 and 9) on taking of salmon, herring, crab and other fish and invertebrates.

10500-10931. Definition and regulation of refuge for marine life, game, birds, and fish. There are no refuges designated under this section in the study area.

106, Appendix. Definition of navigable waters to include streams and sloughs south of Eureka which were used for floating logs or timber prior to 2 January 1873, and slough south of Humboldt Point with 2 feet of water and wide enough to float a boat with 5 tons of freight.

Under Section 30411 of the California Coastal Act (See Coastal Commission below), DFG is empowered to study degraded wetlands and to identify those which can be most easily restored in conjunction with development of a boating facility.* In the study area DFG has four major active programs: (1) enhancement, salmon and trout hatcheries; (2) near-shore salmon migration/population study with ocean sampling; (3) evaluation of mussel culture potential; and (4) inland fisheries in tributary streams. Under Senate Concurrent Resolution No. 28, DFG would prepare a plan for the preservation, protection, restoration, acquisition, and management of wetlands by 1983.

Department of Forestry, State Board of Forestry

The Board has regulatory authority over harvesting of timber on state and private lands and issues timber harvest and burning permits. The Department provides advice to local agencies on resource management, fire protection, and presuppression planning for public use and wildlife areas. The Department has no direct interest in the study area, but its regulation of timber harvest in the forests east of Humboldt Bay may seriously affect the study area economy.

*See Appendix A-6 for the Department's "working definition" of wetlands and Section III.B, Volume III, for a discussion of wetland definitions.

Department of Boating and Waterways (DBW)

The Department makes studies on problems of beach erosion and means for the stabilization of beaches and shoreline areas (as authorized by the State Harbors and Navigation Code), plans and develops small craft harbors and connecting waterways, and regulates boat brokerage practices, including the licensing of persons engaged in such business. DBW publishes public information documents on location and type of boating facilities in the State and on boating safety regulations and guidelines. The Department can make loans for boat launch and marina facilities and administers state and federal aid programs for boating safety. DBW lists 14 facilities in Humboldt Bay which provide boating access or supplies (DBW, 1976). The Department reviews proposed projects for compliance with the shoreline erosion protection policy (Resources Agency, 1978; Satow, 1979, personal communication). In the Humboldt Bay study area, DBW is concerned about erosion at Buhne Point and is discussing control measures with Humboldt County and the Corps of Engineers.

Department of Parks and Recreation (DPR)

The Department is responsible for the acquisition, development, and operation of the State Park System and is also responsible for the administration of grants for recreation to local government. The Parks and Recreation Commission, part of the Department, establishes general policies for the management of the State Park System. Units of the State Park System in the Humboldt Bay study area are Fort Humboldt State Park and the State Azalea Reserve, just north of the Mad River (See Section VIII-A, Cultural Resources, 4. Recreation). In the Coastline Preservation and Recreation Plan (DPR, 1971), Humboldt Bay was identified as coastal salt marsh, and South Humboldt Bay was proposed as a state park (Plate 22, Section VIII-A). DPR also proposed some expansion of the State Azalea Reserve. Under Section 31350 of the State Coastal Conservancy Act (Ch. 1441, Stat. of 1976), DPR is authorized to acquire and hold key coastal resource lands which would otherwise be lost to public use.

The Department undertakes general, long-range statewide planning for recreation supply and demand, preservation of landscape resources, and cultural resource preservation. DPR maintains a park and recreation information system (PARIS) which contains an inventory of existing recreation facilities in California and methods for estimating recreation demand and analyzing demand versus supply to determine deficits in recreation facilities.

The Department developed the California Outdoor Recreation Resources Plan (CORRP) (DPR, 1974) which contains policy and recommendations for development of outdoor recreation in the state. The

Humboldt Bay study area is in Planning District 1, encompassing Del Norte, Humboldt, Mendocino, and Lake Counties. Planning District 1 was found to be deficient in local and regional parks (CORRP, p. 27). In CORRP, priorities for providing state capital funds and grants to local agencies for recreation development were established. For state capital outlays, projects on the coastline in District 1 were fifth in priority in comparison to other Districts. Within District 1, the first two priorities for grants to local agencies were (1) for areas to provide public access to and preservation of ocean and bay frontage and (2) for areas to provide public access to and preservation of tidal marshes, lagoons, bays, or estuaries. The highest demand for outdoor recreation activities among residents of District 1 was for driving for pleasure; play sports and games was second (CORRP, p. 67). Other popular activities include swimming, camping, fishing, hunting, picnicking, boating and walking for pleasure/sightseeing. The greatest deficiencies in District 1 were in picnicking and camping areas (CORRP, p. 99). Recommendations for acquisition and development of recreation facilities were to encourage development by private enterprise and to preserve riparian greenbelt areas in urban centers.

Department of Water Resources (DWR)

The Department provides leadership and assistance to effectively conserve, develop and manage California's water resources. It administers the State's flood control program and supervises the safety of dams. It also reviews federal reports, cooperates in western states water planning, and provides technical services and advice on geologic hazards, recreation development and biological productivity relating to water projects and information on ground-water availability.

DWR has an ongoing land use mapping program, which includes urban and rural lands and has mapped land use in the coastal zone (DWR, 1978). Land use categories mapped by DWR in the coastal zone include: agricultural lands by type (grain crop, field crops, truck crops, pasture, idle, etc.); native classes (vegetated, riparian, water, barren); urban classes (residential, commercial, industrial); and recreational classes (camp and trailer areas, commercial, etc.). Of about 57,700 acres in the coastal zone in the Humboldt Bay area, about 18,300 acres (32%) are in agriculture, about 5000 (9%) are in urban-type uses, and the remainder are in native classes (DWR, 1978).

California Coastal Commission, North Coast Region (CCNCR)

The California Coastal Commission was created by the California Coastal Act of 1976 (Ch. 1330, Stat. of 1976). This Act

constitutes California's coastal zone management (CZM) program in the coastal zone for purposes of the Federal CZM Act of 1972 (16 USC 1457). The Act replaced the California Coastal Zone Conservation Commission (established by the California Coastal Zone Conservation Act of 1972) with the Coastal Commission. The Coastal Act is summarized in Appendix A. The Federal CZM Act of 1972 requires federal actions to be "consistent to the maximum extent practicable" with the State Coastal Management Program.

As mandated by the Coastal Act, the Coastal Commission has two major functions: (1) planning for the development and conservation of coastal resources as part of a federal coastal zone management program; and (2) exercising permit review for proposed development projects in the coastal zone. As part of its planning function, the CC issued regulations for preparation of local coastal programs in May 1977. The local governmental entities in the study area are presently preparing local coastal programs (LCP) under these regulations (see Local Government below). The Corps of Engineers has responsibility for coastal management and issuance of permits in compliance with Coastal Commission requirements.

The North Coast Regional Commission (CCNCR) is engaged in coastal planning for the study area. The CCNCR has established the Humboldt Bay Advisory Committee, whose function is to coordinate local government efforts in developing LCP's, to provide a forum for conflict resolution, and to advise the commission on local coastal issues. The CCNCR has identified coastal planning issues in the Humboldt Bay study area (CCNCR, 1978(1)); these are summarized below:

1. Access. The North Spit has limited public access. Easy access by off-road vehicles may impact dune habitats. Little of the shoreline of Humboldt Bay is accessible. Areas proposed for public access (Elk River Spit, Eureka waterfront, bayshore dikes in north and south bays) are privately owned.
2. Recreation and Visitor Facilities. Only the South Spit has major recreation facilities. Humboldt County has a boat ramp on North Spit. There is little provision elsewhere for recreational use (See Section VIII-A-3, Recreation).
3. Housing. Local governments need more specific plans for coastal zone housing.
4. Water and Marine Resources. Riparian vegetation in the study area is not protected by plans or zoning. Water quality and marine resources are degraded by non-point source pollution discharges (agricultural wastes, septic tank leachate, urban runoff, etc.).

5. Diking, Dredging, Filling, Shoreline Structures. There is no consistent regulation of these activities in wetlands. The Bay area lacks an area suitable for dredged material disposal in small amounts. Compensation for wetlands loss or degradation is difficult because of problems in locating areas suited for wetland restoration. Shoreline erosion is a problem in King Salmon and on North Spit; erosion control projects need review.
6. Commercial Fishing and Recreational Boating. The need for additional boat berths should be reviewed and good locations identified. No areas for boating support developments have been noted. Expansion of aquaculture may be limited by water quality or habitat conflicts; specific plans for aquaculture should be made.
7. Environmentally Sensitive Habitat Areas. Dune forests on the North Spit (a unique habitat) and wetlands and submerged lands are not presently protected.
8. Agriculture. Most agricultural land is planned for agricultural use, but zoning may not maintain it. Current plans and existing development do not always provide a stable boundary between urban and rural agricultural uses.
9. Industrial Development and Energy Facilities. Areas in Fields Landing, King Salmon, Bucksport, Eureka, and North Spit are planned for industrial use; however, the planning may have been inconsistent in estimating requirements and avoiding environmental damage. Areas should be reserved for development of power generating facilities and for OCS-related development. Opportunities to consolidate berthing for petroleum storage and transport facilities on the Bay's east shore should be reviewed.

As part of its planning function, the CCNCR has prepared several studies and policy statements on wetlands in the Humboldt Bay study area. In 1978 the CCNCR prepared a study of land use and habitat values in the Broadway wetlands area west of Broadway - Highway 101 from south of Bucksport to north of the Eureka Brat Basin (CCNCR, 1978(2)). In this area (total 631.6 acres), there were 301.2 acres (48%) developed in port-related and industrial use, 171.3 acres (27%) vacant/fill, and 159.1 acres (25%) wetlands (based on vegetation indicators). A study map of the Broadway area is available from the CCNCR in Eureka. The CCNCR examined wetlands values based on biological productivity, valuable and rare species, relative quantity, and replaceability and ranked Humboldt Bay wetland habitat types

from greatest to least value as follows: vegetated subtidal (eel-grass and other vegetation), vegetated intertidal (saltmarsh), freshwater/brackish marsh, unvegetated intertidal (mud flats), unvegetated subtidal (open bay waters), periodically flooded pastures. The CCNCR has also developed a species index, showing species use by habitat type, for use in wetland evaluation.

The policies of the Coastal Commission on wetlands, environmentally sensitive areas, and other resources are included in Sections 30231, 30233, and 30240 of the Coastal Act. Section 30231 deals with the protection of biological productivity and water quality; to this end, measures to control runoff, preserve groundwater supplies, encourage wastewater reclamation, maintain natural vegetation buffer areas for riparian habitat, and minimizing alteration of natural streams will be used. Section 30233 allows diking, dredging, and filling of coastal waters and wetlands for specific activities under certain conditions; in degraded wetlands as identified by DFG, boating facilities may involve diking, dredging, or filling if a substantial portion of the degraded wetland is restored and maintained as biologically productive. Section 30240 deals with protection of environmentally sensitive habitat areas. Coastal Commission policy on location of new development is partly contained in Section 30250, which calls for new development to be located in proximity to (or contiguous with) existing developed areas or areas with adequate public services and where coastal resources will not be adversely affected.

Guidelines of the CCNCR for permit requests in wetlands and other areas of the Humboldt Bay study area include the following:

- 1) Impacts of any proposed fill should be evaluated in the context of the entire Humboldt Bay ecosystem rather than solely on a case-by-case basis. Evaluation criteria should include effects on consumptive and nonconsumptive values, on rare or essential species or habitats, and on water quality and biological productivity (CCNCR, 1978(4)).
- 2) Bottomlands should be protected and uses should be limited to agriculture as much as possible (Ray, 1979, personal communication).
- 3) Mitigation for fill projects has included purchase and dedication of adjacent wetlands and restoration of degraded wetlands (CCNCR, 1978(4)).
- 4) Runoff from urbanized areas should be controlled; in the past, construction of dikes and leach fields has been required to minimize runoff and water quality impacts. (Ray, 1979, personal communication; CCNCR, 1978(4).)

- 5) City of Eureka wetlands policy (CCNCR, 1978(3))* . Drainage ditches are not wetlands. Fill may be permitted in wetlands on a case-by-case basis if it is part of a restoration program. Fill in off-site restoration must be part of a program providing habitat value equal to or greater than that of the filled area.

As stated above, the Coastal Commission, North Coast Region, has permit authority in the coastal zone. The coastal zone boundary is shown on Plate 16. Most coastal development requires a permit; exemptions are defined in the Coastal Act, Section 30610. The CCNCR has reviewed numerous permit applications in the study area (CCNCR, 1978(1)); general points of concern in permit review include:

- . identifying public access to shoreline
- . preserving recreation and low-cost visitor serving facilities
- . protecting environmentally sensitive habitat areas
- . protecting sites for industrial and energy facilities
- . maintaining and encouraging low and moderate cost housing
- . preserving lands in agriculture
- . identifying hazard areas
- . expanding and conditioning commercial fishing and recreational boating
- . protecting visual resources and special communities
- . protecting wetlands from dike and fill and requiring compensation for lost wetlands and conditions

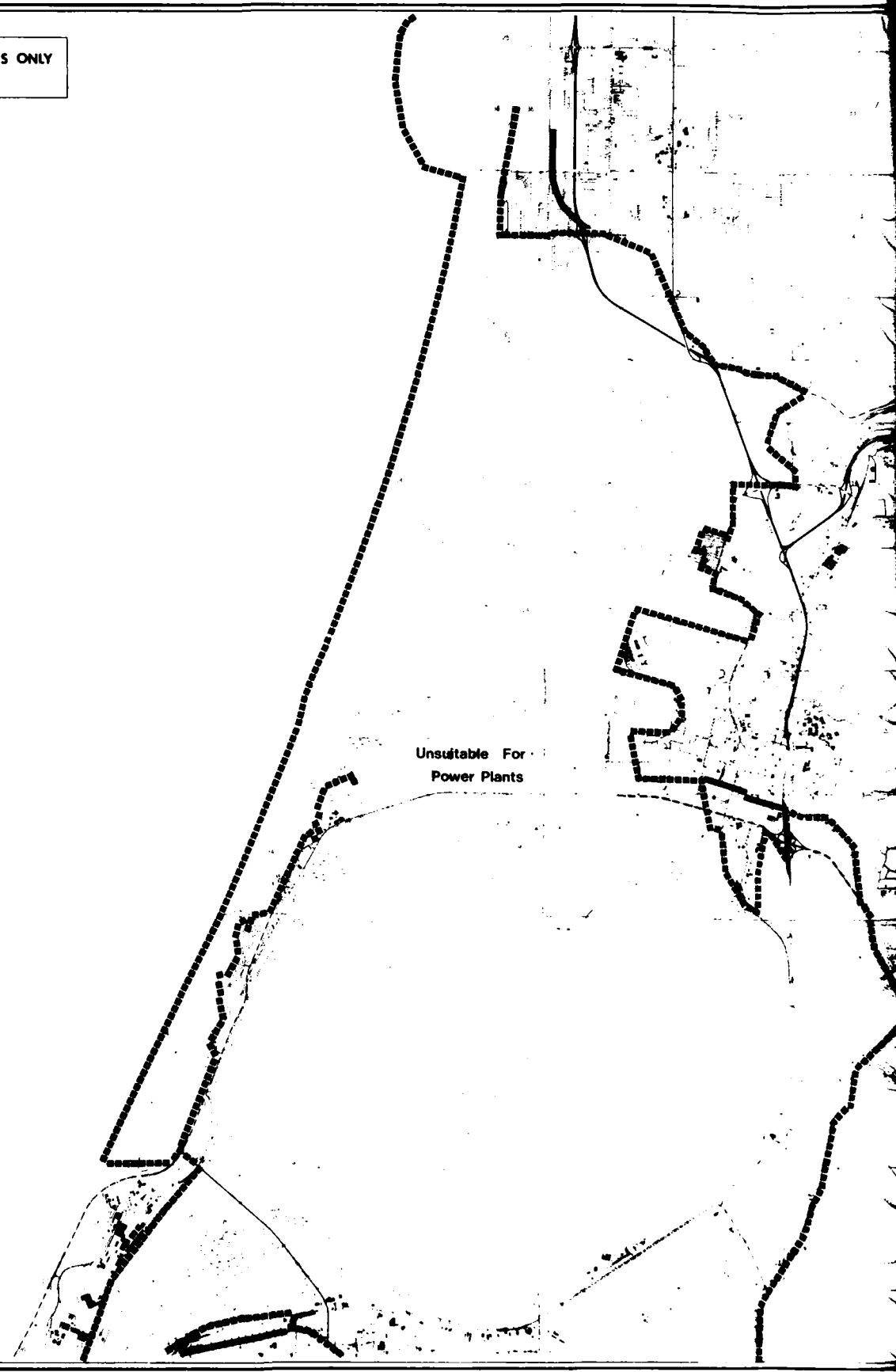
[Coastal Commission permits and conditions discussed in more detail in Section IV and V-C.]

Under Section 30519 of the Coastal Act, upon approval and certification of a local government's LCP, the Coastal Commission must delegate its permit authority to that local government, except for (1) any development proposed on tidelands, submerged lands, or public trust lands (filled or unfilled) in the coastal zone, (2) any development in ports under Section 30700 et seq., and (3) any development in state universities or colleges in the coastal zone. Thus,

* This policy was under review as of November 1979 and may be changed or dropped.

FOR PLANNING PURPOSES ONLY
NOT FOR LEGAL USE



Unsuitable For
Power Plants

A map of a geographical area, possibly a coastal region, with a large area outlined by a dashed line. The area is labeled "Unsuitable For Power Plants". The map includes a grid and various geographical features like rivers and land parcels. The text "FOR PLANNING PURPOSES ONLY NOT FOR LEGAL USE" is in the top left corner.

COASTAL ZONE

PLATE NO 16 NORTH

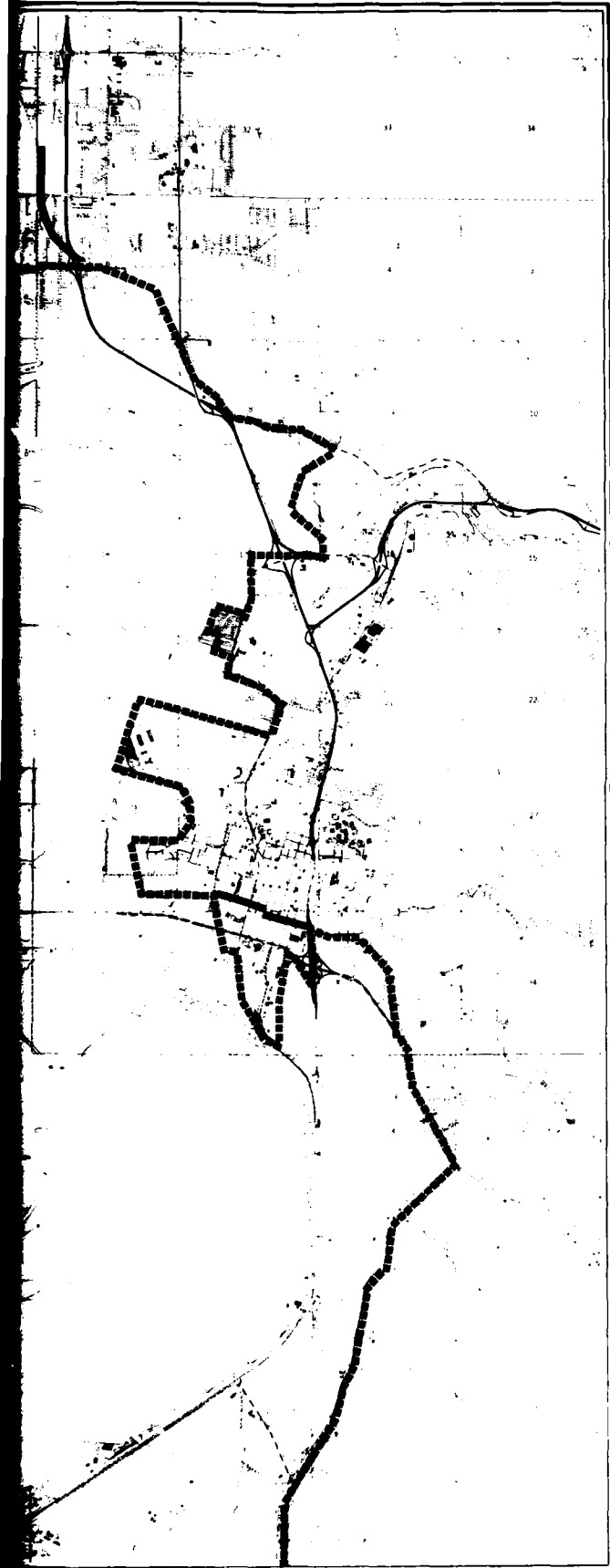
LEGEND

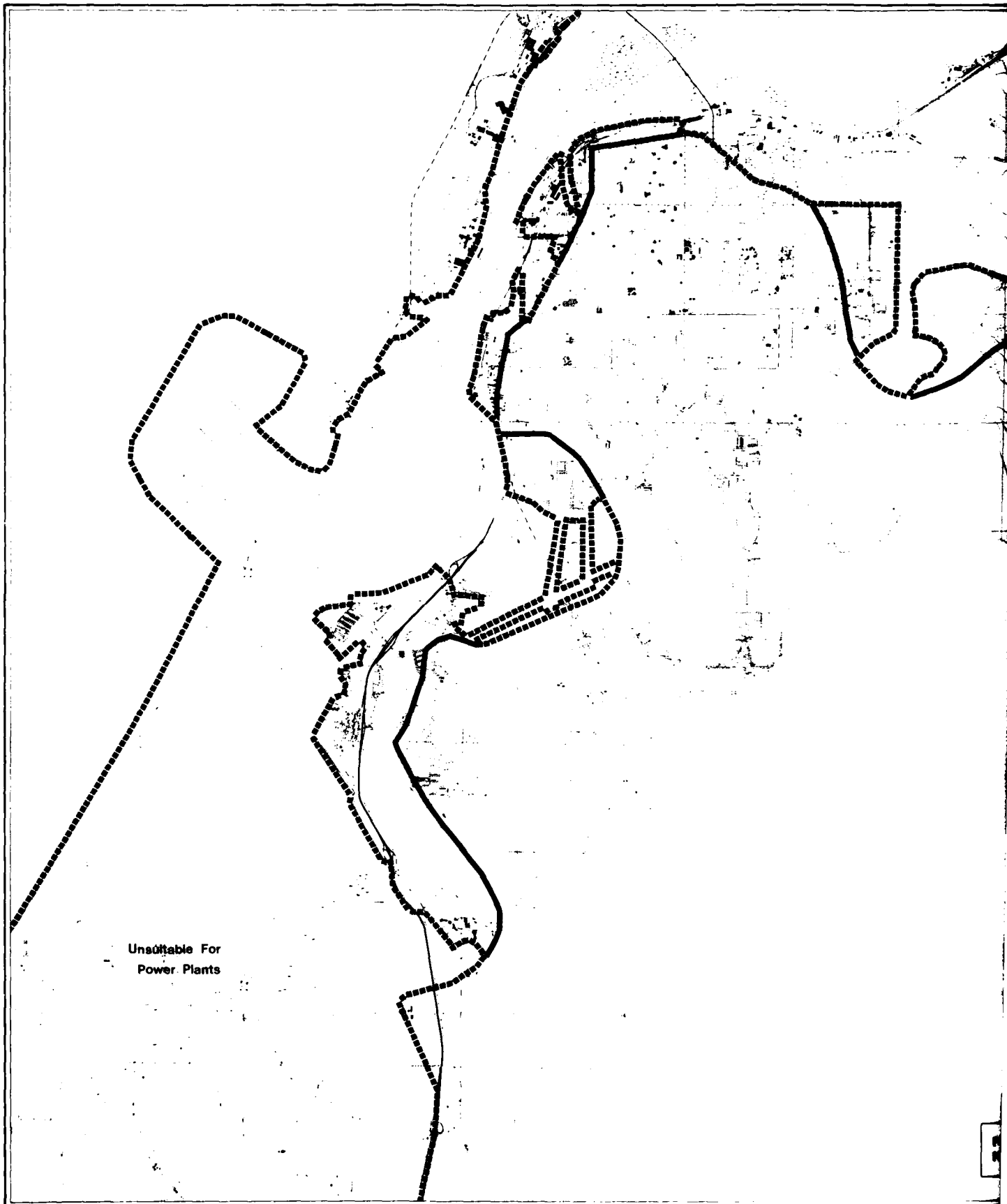
-  Coastal Zone Boundary
-  Unsuitable For Power Plants



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: California Coastal Commission
Energy Resources Conservation
and Development Commission





Unsuitable For
Power Plants

COASTAL ZONE

PLATE NO 16 SOUTH

LEGEND

— Coastal Zone Boundary

Unsuitable For Power Plants



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: California Coastal Commission
Energy Resources Conservation
and Development Commission

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the Coastal Commission retains regulatory responsibility over tide, submerged, and public trust lands. There is, however, an exception to this general rule: permit authority over tide, submerged, and public trust lands shall be delegated to the local government for any development sponsored by a port or harbor district on lands or waters granted by the legislature to that local government if the certified LCP includes the specific development plans of such port or harbor district. The implication is that if no specific development plans of the Harbor District are incorporated in the LCP's of Eureka or Arcata, then permit authority in granted tide, submerged, and public trust lands would not be delegated to the cities but would remain with the Coastal Commission. According to a representative of the CCNCR, permit authority is only delegated to local government if the project is to be carried out by the Harbor District on tidelands granted to city or county government. Humboldt County does not hold any granted lands (Vander Naillen, 1978; Fischer, 1978).

State Coastal Conservancy

The Coastal Conservancy was authorized in 1976 (Chapt. 1441, Stat. of 1976) with an initial appropriation of \$10 million from the 1976 Park Bond Act. Its responsibility is to implement a program of agricultural protection, area restoration, and resource enhancement in the coastal zone consistent with the 1976 Coastal Act. The Conservancy can acquire sensitive coastal lands and authorize grants to local governments for the purpose of acquiring and restoring coastal properties jeopardized by development. It can give grants to state agencies for acquisition of lands in resource protection zones (as defined by those agencies). Grants may also be made for acquisition of public accessways. In the study area the Conservancy has awarded funds to the City of Arcata for the acquisition of land and creation of a 63 acre freshwater marsh (See Section VIII-A-3, Recreation).

California Energy Commission (CEC), formerly the Energy Resources Conservation and Development Commission (ERCDC)

The Commission has five major responsibilities: planning and forecasting for California's energy requirements; energy resource conservation; power plant facility and site certification; research and development of alternatives to fossil fuel and electrical energy from sources such as solar, geothermal, and nuclear energy; and energy shortage contingency planning.

The Commission has exclusive regulatory authority over the siting of all thermal power plants and related facilities. CEC certifies the siting of all new power plants and changes or additions to existing plants. On 5 September 1978 the Coastal Commission adopted its staff recommendations of areas designated as not suitable for siting new power plants or related facilities under Section 30413(b) of the Coastal Act. Specifically, areas were designated in

which the location of thermal electric power plants of generating capacity greater than 50 megawatts and related facilities would cause significant adverse effects on valuable coastal resources. The designated areas in and around Humboldt Bay are shown in Plate 16. Valuable coastal resources identified include: (1) publicly owned parks; (2) other recreation areas; (3) wetlands and estuaries; (4) marine life refuges and reserves, ecological reserves, areas of special biological significance; (5) marine resources (kelp beds, rocky intertidal and subtidal, mouths of anadromous fish streams); (6) marine mammal and seabird breeding and resting areas; (7) environmentally sensitive areas; (7-10) wildlife habitat, cultivated agricultural land; (8) California Natural Areas Coordinating Council areas (see below); (9) Forestry special treatment areas; (10) cultivated agriculture, special agrarian communities; (11) view protection; (12) inadequate public services; and (13) riparian vegetation. Of these resources, areas in the study area contain 1, 2, 3, 4, 7-10, 8, 11, and 13, according to Coastal Commission maps.

After designations are adopted by the Coastal Commission, the CEC cannot approve a new power plant site in a designated area without Coastal Commission approval. The Coastal Commission may approve new facilities in designated areas if the Commission finds the facility would not significantly damage coastal resources. Designations will be revised prior to 1980 and every two years thereafter.

The California Natural Areas Coordinating Council (CNACC), a group based in Sonoma, California, conducted an inventory of California natural areas which was completed in 1978 (CNACC, 1978). The inventory was funded in part by the California Energy Commission and the results are used by the CEC staff in decisions on power plant siting and reviews of permit applications and environmental impact reports. There are nine identified natural areas in the study area; they are as follows: 120175 - Arcata Bay North mudflats; 120198 - Azalea Reserve (just outside study area); 120370 - land of College of the Redwoods; 120590 - Eureka Slough; 120795 - Indian (Gunther) Island; 120893 - Humboldt Bay National Wildlife Refuge (north and south bay, Plate 18); 121212 - Lanphere-Christensen Dunes (Plate 18); 121310 - Mad River Slough; and 121315 - Manila Dunes (south of Lanphere-Christensen Dunes). These areas were identified for characteristics such as northern coastal salt marsh, tidal flats, birds (water fowl, seasonal/breeding concentrations), plants (rare, endangered, unusual concentration), freshwater marsh, shore pine forest, coastal foredunes, and coastal brackish marsh (CNACC, 1978).

CEC prepares the Biennial Report which includes energy conservation policies and measures, analysis of energy supply and demand projections, and recommendations for coordination of planning to relieve energy shortages. In the draft Biennial Report, 11 gener-

ic issues of concern to CEC are identified; these issues are considered general and resolvable (Maul, 1979, personal communication). They are as follows:

1. Air quality and the impacts of fossil fuels; tradeoff in emissions.
2. Water supply; competition for use of fresh water, possible use of waste water.
3. Solid waste disposal, particularly nuclear.
4. Coastal resources; possibility of energy development in undesignated areas.
5. Public health; impact of air pollution above standard, tradeoff of emissions, hydrogen sulfide emissions.
6. Wetlands and endangered species; the CEC does not necessarily recognize the Resources Agency policy on wetlands, however, the cumulative loss of wetlands to development and adverse impacts on wetlands are a real concern to the CEC. In defining feasibility of power plant sites, the CEC requires information on general wetland characteristics, wildlife value, relationship to other wetlands, alternatives, and compensation areas. The wetlands issue is viewed as the major issue to be resolved. (Therkelsen, 1979, personal communication.)
7. Socioeconomic problems; fiscal impacts, demand for services preceding receipt of tax money from development.
8. Geotechnical concerns and public safety; seismicity and location of nuclear plants, regulatory differences between NRC and CEC, earthquakes and reliability.
9. Land area designations by other agencies; e.g., BLM may designate areas as wilderness.
10. Regional equity; location of power plants and balance of impacts/benefits.
11. Agricultural lands; importance and relationship to power plants.

The CEC is interested in new or supplementary methods of power generation and can potentially provide support or participation in demonstration projects for power generation, such as the possible chip-burning power plant of North Coast Export Company on the North Spit.

State Lands Commission (SLC)

Chapter 5, Statutes of 1938, First Extraordinary Session, created the State Lands Commission. Under the provisions of Section 6301 of the Public Resources Code, the Commission has exclusive jurisdiction over all ungranted tidelands and submerged lands owned by the State, and of the beds of navigable rivers, streams, lakes, bays, estuaries, inlets, streams and swamp and overflowed lands. As described in Section VII-B, Ownership, all tidelands and submerged lands in the study area have now been granted. As to granted lands, Section 6301 of the Code stipulates that all jurisdiction and authority remaining in the State as to tidelands and submerged lands of which grants have been or may be made is vested in the Commission. However, exactly what jurisdiction and authority remains with the State is unclear, and the SLC has recommended legislation to clarify the respective roles of the SLC and the granted lands trustees and to establish a program for sustained investigation, policing and review of the administration of granted tide and submerged lands by trustees (SLC, 1976). The NOS is conducting a tidal gauging program to provide more tidal datum information in Humboldt Bay for the SLC.

As mentioned in Section VII-B, trustees have a general duty to "substantially improve" granted lands. The responsibility of determining whether granted tide and submerged lands have been "substantially improved" was given to the State Lands Commission. If the Commission finds that this condition of any grant has not been fulfilled, provision is made for the revocation of the trust provisions and reversion of the granted lands to the control of the State. The SLC has found that only a small fraction of the granted acreage is actually used and improved by the trustees. The SLC is recommending that granted lands not actually needed or planned for be reverted to State control (SLC, 1976). (Note: the proposed legislation does not speak to the role of the SLC in managing granted lands.)

On State tide and submerged lands, the SLC regulates the full range of land use activities including: oil and gas exploration and production operations; sand, gravel and other mineral resource development; dredging, diking and filling activity; and the siting and construction of wharves, piers, seawalls, breakwaters, and other structures or facilities. This authority is exercised through leases, permits, licenses, easements and other contractual arrangements. The SLC has administrative policies for protection of the lands and resources under SLC jurisdiction in the coastal zone (CAC, Title 2, Div. 3, Act 6.5) including the following:

- . Maintenance of marine resources
- . Biological productivity
- . Protection against oil spills
- . Dredging, diking, and filling generally, in estuaries and in wetlands

- . Disposal of dredged material
- . Seawalls, breakwaters, and shoreline structures
- . Commercial fishing and recreational facilities
- . Sand replenishment
- . Major projects affecting coastal streams
- . Development controls for environmentally sensitive areas
- . Archaeological and paleontological resources
- . Location of new development
- . Protection of visual quality
- . Geologic, flood, and fire hazard
- . Coastal-dependent development
- . Recreational boating
- . Coastal-dependent industry
- . Tanker terminals, and operating procedures
- . Siting and design of liquified natural gas and petroleum facilities
- . Refineries and petrochemical facilities
- . Public access to the coast
- . Review of local coastal programs

The State Lands Division (staff of the SLC) identified tide and submerged lands of significant environmental values (SLC 1975). Elements of significant environmental value include:

1. Geological
2. Paleontological
3. Scenic or aesthetic
4. Watershed
5. Rare or endangered species
6. Critical ecosystem
7. Fishery and wildlife habitat
8. Recreational
9. Biological
10. Rare or endangered plants
11. Rare or precious mineral source
12. Speleological

13. Fish spawning and nursery
14. Critical water source
15. Seasonal wildlife support areas
16. Archaeological/historical including landmark
17. Unique
18. Exceptional
19. Textbook example
20. Popular object
21. Contributory

Areas were classified as follows:

CLASS A - Restricted Use

Areas where public use should be minimized to preserve the integrity of the natural environment as a whole.

CLASS B - Limited Use

Areas in which one or more closely related dominant, significant environmental values is present. Limited use compatible with and non-consumptive of such values may be permitted.

CLASS C - Multiple Use

Areas currently in multiple use which are less susceptible to environmental degradation than are Classes A and B, but nevertheless do possess significant environmental values.

In the study area, the following areas were identified by the SLC:

- *1. Humboldt Bay including Arcata Bay: Use Class C; meets elements 3, 5-10, 13, 15, 17-21
- *2. Humboldt Bay, North Bay: Use Class C; meets elements 3, 5-10, 13, 15, 17-21
3. Humboldt Bay, South Bay: Use Class A; meets elements 1, 3, 5-10, 13, 15, 17-21
4. Mad River (all): Use Class B; meets elements 3, 7-10, 13, 15, 18, 20

Air Resources Board (ARB) and Air Pollution Control Council

The Air Resources Board (ARB) has responsibility for implementing state and federal legislation directed toward the attainment

*Note: #'s 1 and 2 are the same but are listed separately in the source document (SLC, 1975).

and maintenance of state and national ambient air quality standards. The ARB has sole responsibility for regulating mobile sources (vehicular) of air pollution and backup authority over stationary sources (nonvehicular). Local and air pollution control districts (APCD) have primary responsibility for regulating emissions from stationary sources of pollution. The Humboldt Bay study area is in the Humboldt County Air Pollution Control District (see Local Agencies below).

California is divided into 14 air basins; the study area is in the North Coast Air Basin, composed of Humboldt, Del Norte, Trinity, Sonoma, and Mendocino Counties. Each County has an established APCD. Air basins with several APCD's must have a control council composed of elected officials designated by the APCD's. The primary duty of this council is the adoption, review, and update of a basin-wide air pollution control plan.

The ARB is preparing the second edition of the State Implementation Plan (SIP), which will incorporate the Air Conservation Program, locally adopted Air Quality Maintenance Plans (AQMP), Basinwide Air Pollution Control Plans, Transportation Control Plans, Non-Attainment Plans, and Emergency Plans.

Important parts of the SIP for the study area are the Basinwide Air Pollution Control Plan, the Non-Attainment Plan, and the Air Conservation Program.

The Basinwide Air Pollution Control Plan was prepared by the Air Pollution Control Council for the North Coast Air Basin (NCAPCC, 1977). The plan describes existing air quality problems and control strategies in the Basin (See the air quality discussion, Section VI.B).

The Plan for Development of an Air Conservation Program (ARB, 1977) was prepared by the ARB in 1976 and revised in 1977 to meet the requirements of EPA for prevention of significant deterioration (PDS) in air quality. However, this plan was prepared before the passage of the Clean Air Act Amendments of 1977, and it may have to be revised to meet new requirements. Humboldt County was declared a nonattainment area by EPA; however this designation may be changed to make a PSD program applicable (Oliva, 1979, personal communication). The Air Conservation Program Plan defines potential area classifications based on existing air quality and suggests policies for ensuring nondeterioration in high quality areas. It also defines issues which must be addressed during the Air Conservation Program development. The Air Conservation Program will meet EPA requirements for air quality data acquisition.

The ARB is developing a non-attainment plan directed toward strategies for achieving attainment of standards by 1982 (Oliva, 1979, personal communication) as required by the Clean Air Act of 1977, Section 172. No draft is available as yet.

State Water Resources Control Board (SWRCB) and Regional Water Quality Control Board, North

Coast Region. The State Water Resources Control Board and the nine Regional Water Quality Control Boards throughout the state are responsible for water quality control under the FWPCA of 1972 (PL 92-500) and California's Porter-Cologne Water Quality Control Act. The state and regional boards regulate all waste discharge which may affect waters of the State, including surface and ground waters. The State Board certifies waste water treatment plant operators, registers liquid waste haulers and administers state and federal grants for construction of wastewater treatment facilities. The Regional Boards have primary responsibility for regulating wastewater discharges, including discharges from all point and non-point sources, for regulating any dredging, filling, diking or soils disposal through adoption of waste discharge requirements, and for enforcing these requirements through appropriate administrative action including cease and desist orders and cleanup and abatement orders. The Regional Board places specific conditions on waste discharges, including effluent limitations and receiving water limitations and may require monitoring of effluent and receiving waters to ensure compliance with limitations; an example is Order No. 76-87 of the Regional Board, concerning waste discharge requirements for the dredging of the proposed Humboldt Harbor Marina (Woodley Island Marina). The Regional Board requires contingency plans for management of accidental spills from all entities engaged in waste discharge, conveyance, storage, and/or management. The Humboldt Bay study area is under the North Coast Regional Board.

The SWRCB has adopted several water quality plans and policies, as follows (SWRCB, 1975(1)):

1. The State Policy for Water Quality Control, adopted in 1972, provides general guidance for water quality control planning.
2. State Board Resolution No. 68-16, commonly known as the Non-Degradation Policy, deals with areas in which water quality is already higher than required by adopted water quality standards. The policy provides that such high quality must be maintained unless a change would be consistent with maximum benefit to the people of the State, would not unreasonably affect present and anticipated beneficial use of such water and would not result in water quality less than that prescribed in the standards. Any waste discharge into existing high quality waters would have to have best practicable treatment (BPT) to comply with the non-degradation policy.
3. The Water Quality Control Policy for the Enclosed Bays and Estuaries of California, adopted by the SWRCB in

1974, is a very significant policy for the Humboldt Bay study area. Briefly, the Bays and Estuaries policy calls for the elimination of all waste discharges to enclosed bays and estuaries at the earliest possible date and prohibits any new discharges to these sensitive areas. Discharges will be permitted only if the Regional Board finds that the discharge would enhance the receiving water quality above that occurring in the absence of the discharge. In the Humboldt Bay area, this policy was the principal impetus for the proposed regional sewage treatment and collection system (see Humboldt Bay Wastewater Authority under Local Agencies). The Bays and Estuaries policy has been a source of controversy in the Humboldt Bay area, and public hearings were held in April 1979 to determine whether this policy should continue to apply to Humboldt Bay. The SWRCB confirmed the policy as reasonable and appropriate for Humboldt Bay. The Board promulgated interpretations of the enhancement provision of the policy specific to Humboldt Bay as follows: the enhancement provision requires (1) full secondary treatment, with disinfection and dechlorination, of sewage discharges, (2) compliance with any additional NPDES permit requirements issued by the Regional Board to protect beneficial uses, and (3) the fuller realization of existing beneficial uses or the creation of new beneficial uses either by or in conjunction with a wastewater treatment project (for example, the creation of additional marshlands or wetlands). The SWRCB felt that the Arcata marsh enhancement project (see City of Arcata below and Section VIII.A.3, Recreation) may enhance the water quality of Humboldt Bay, but that a conclusive determination of enhancement could not be made until the study results, including monitoring data, were available.

4. Water quality control plans were adopted in 1971 and 1972 applying to ocean waters (the Ocean Plan) and to control of temperature in coastal and interstate waters, bays, and estuaries (the Thermal Plan). The Ocean Plan has been revised and a new version adopted in 1978 (SWRCB, 1978); it is more detailed and stringent in its requirements. The Thermal Plan was also revised (SWRCB, 1975(2)). Both the Thermal Plan and the Ocean Plan contain specific water quality objectives and discharge limitations and requirements.
5. The policy on the use and disposal of inland waters used for power-plant cooling (SWRCB, 1975(2)) calls for the use of wastewaters, ocean waters, or brackish waters for powerplant cooling in preference to fresh inland waters. The policy also prohibits discharges of blowdown waters to land disposal sites and discharges

of wastewaters from once-through inland power plant cooling facilities.

6. Areas of Special Biological Significance were designated by the SWRCB in 1974 and 1975 (SWRCB, 1976); none are located in or near the Humboldt Bay study area.

These policies are followed by the Regional Boards.

The State Board and Regional Boards prepared and adopted Water Quality Control Plans (Basin Plans) for California's 16 hydrologic basins. The Basin Plans include analysis of past and present water usage and quality problems, water quality control objectives, and an implementation program. The Humboldt Bay study area is in the North Coast Basin 1B. The North Coast Basin Water Quality Control Plan was prepared in 1975 (SWRCB, 1975(1)). The Basin Plan identified beneficial uses of the Humboldt Bay study area as agricultural and industrial water supply, navigation, recreation, commercial and sport fishing, habitat for wildlife and rare or endangered species, marine and freshwater habitat, fish migration and spawning, and shellfish harvesting. The plan lists water quality objectives and standards and describes point and non-point source control measures. The Basic Plan describes an action plan for the Humboldt Bay area, directed toward phase out of discharges of municipal wastewaters and industrial process waters and toward secondary treatment of municipal wastes. Guidelines, criteria, and action plans are specified for individual waste treatment and disposal facilities (such as septic tanks), solid wastes, point source agricultural wastewaters such as feedlots or dairy operations, mining wastes, and the nonpoint sources of logging, construction and associated activities.

Non-point source pollution falls under Section 208, FWPCA; in the study area, the principal non-point sources of concern are agricultural and urban runoff and septic tank problems. The Basin Plan does not deal with 208-type agricultural runoff. The State and Regional Boards are preparing a 208 plan for the Humboldt Bay area; a work plan has been completed. The state is proposing a contract with the Humboldt County Farm Bureau for an analysis of animal waste management practices and a review report on problems, including periodically and frequently flooded dairy lands (Hannum, 1979, personal communication). An emphasis in 208 planning is on best management practices (BMP): the effects of BMP on receiving waters and whether effects are beneficial (Heiman, 1979, personal communication). There is some feeling in the study area that non-point agricultural runoff provides beneficial nutrients to the Bay (Kuiper, 1979, personal communication). A staff review report on capabilities of soils for septic tanks and septic tank permitting procedures and conditions has been prepared as part of the 208 effort (Hantzsche and Wistrom, 1978).

Issues of general concern to the SWRCB and North Coast Regional Board include the following (Lewis, 1979, personal communication; Hannum, 1979, personal communication; Heiman, 1979, personal communication):

- . The regional sewage treatment system and the Bays and Estuaries policy. The system was not meant to promote growth. If local agencies act to institute individual sewage management plans, it must be shown that enhancement of Bay waters will result.
- . Water quality and circulation in the Bay (the Regional Board has conducted some dye studies of the North Bay (Hannum, 1979, personal communication)).
- . Sedimentation. Type and amount in the Bay. Will silviculture programs in Humboldt County reduce sediment in the Bay? Is high sediment discharge to the Bay bad?
- . Septic tank capabilities and pollution control around the Bay.
- . A few remaining industrial discharges to the Bay. Hannum (1979) noted that serious efforts to comply with discharge requirements had been made by all industries.
- . Dredged material disposal criteria in the Bay.
- . Data and analysis of animal waste management practices and pasture flooding.

Department of Transportation (Caltrans)

Caltrans has both regulatory and planning authority in the study area. The agency grants permits for access locations, advertising signs, vehicles exceeding provisions of the vehicle code, and other activities on State highways. Caltrans is responsible for preparation of the California Transportation Plan for achieving a coordinated and balanced statewide transportation system including mass transit, highway, aviation, maritime, and railroad systems. This plan is not yet complete. A Regional Transportation Plan which includes the Humboldt Bay study area has been adopted by the Humboldt County Association of Governments, the regional transportation planning agency.

Caltrans recently (August, 1978) completed a Memorandum of Understanding with the ARB to establish a mechanism for determining consistency of transportation plans and projects with air quality requirements (ARB, 1978(3)).

Caltrans is responsible for the planning, design, construction, and maintenance of the State highway system and related facilities. The Caltrans six-year planning program identifies five projects in the Humboldt Bay study area (Caltrans, 1978). Four of these are along Highway 101; two are for resurfacing. The other two Highway 101 projects involve the construction of an Elk River Road interchange and funding of marsh mitigation for the effects of the interchange construction. The fifth project is for construction of the Mad River Slough Bridge and bridge approaches on Highway 255 west of Arcata. As described earlier, the FHWA has completed a report on the environmental effects of this project. Recommendations for compensation/mitigation of adverse effects include the reversion of diked pasture to wetland, to offset the loss of saltmarsh resulting from the proposed bridge construction. Caltrans is presently in the process of acquiring a 17-acre parcel on the west side of the Elk River at Elk River Corners; eleven acres of this parcel will be used as compensation for Caltrans projects including the Mad River Slough Bridge (Ray, 1979, personal communication).

Office of Planning and Research (OPR)

Together with the Resources Agency, the OPR is the agency with most general responsibility for the California Environmental Quality Act and its implementation. OPR prepares and reviews guidelines for evaluation of proposed projects and preparation of environmental impact reports. OPR has responsibility for monitoring the planning activities of local governments for compliance with the State Planning and Zoning Law and for preparing the updating the guidelines for local general plans. Under the 1976 Coastal Act, OPR is charged with reviewing state agency implementation of Coastal Act policies and making recommendations to minimize potential duplication and conflicts.

OPR has responsibility for the preparation and updating of the Governor's Environmental Goals and Policy Report. This report contains goals and policies for air quality, land use, noise, pesticides, population, solid waste, transportation, water, and environmental resources and hazards. The report identifies and maps three major types of resource areas: Scenic, Scientific, Educational, and Recreational Resource Areas; Resource Production Areas; and Hazardous Areas. The report also defines Areas of Statewide Interest and Areas of Statewide Critical Concern as areas in which any proposed land use or resource change must be very carefully considered. It further identifies Potential Environmental Resources and Hazards of Critical Concern or Statewide Interest; those specifically identified in the study area are listed below:

- . Humboldt Bay and Mad River - premium waterways (scenic, fishery, wildlife and recreation) identified by the Resources Agency.

- . Historical and archaeological resources - Carson House, Gunther Island Site 67, Fort Humboldt, and Tsahepkw.
- . Areas adjacent to National and State Waterfowl Refuges; this includes areas in North and South Bay.
- . Areas owned by the Nature Conservancy - the Lanphere-Christiansen Dunes.
- . Habitats of all rare and endangered species as identified by the State Department of Fish and Game.

State Historic Preservation Office (SHPO)

The SHPO functions as the state component to carry out the National Historic Preservation Act and to ensure that the historic aspects of projects are in compliance with the California Environmental Quality Act. The SHPO reviews private projects and Corps permit applications for protection and preservation of historic resources. The agency reviews sites for eligibility for the National Register (Bass, 1979, personal communication).

Department of Health

A function of the Department of Health of particular importance in the Humboldt Bay study area is the regulation of shellfish harvesting through regulation of commercial growing areas and the establishment of periodic quarantines over coastal waters when toxic conditions exist. Humboldt Bay has a conditional shellfish harvest certificate because of high coliform levels in storm water runoff. During high runoff periods (whenever there is one-half inch of rain in 24 hours) the Bay is closed for shellfish harvest and remains closed for five days after the runoff event (Hannum, 1979, personal communication).

Humboldt County Association of Governments (HCAOG)

The HCAOG is an association formed in 1968 by the governments of Humboldt County and the various cities, including Eureka and Arcata in the study area. HCAOG has three basic functions: coordinating planning efforts for member governments, doing regional transportation planning, and acting as the regional clearinghouse for city and community grant applications for federal funds. HCAOG has a planning program for small cities, but there are presently no ongoing planning efforts. The agency prepares yearly transportation plans for Humboldt County and is currently cooperating with Caltrans on a Eureka/Arcata transportation corridor study, examining land use patterns and transportation needs on Highway 101 between Eureka and

Arcata. As the regional clearinghouse, HCAOG coordinates and reviews funding applications under grant-in-aid programs under Circular A-95 of the Federal Office of Management and Budget. The agency also reviews projects for environmental impacts.

LOCAL GOVERNMENT

The three major local governments with jurisdiction in the Humboldt Bay study area are Humboldt County and the cities of Eureka and Arcata. (The Harbor District is discussed under Local Special Agencies and Districts below.) The city boundaries are shown on Plate 17. Each entity reviews Corps permit applications and proposed projects within its boundaries and may also review particular projects outside its boundaries. Reviews are made using general plans, zoning, and local coastal program issues as statements of policy. In the following discussion, each governmental entity and its plans and policies of particular interest for this study are briefly described. Zoning is discussed as a separate section for all three entities together.

Humboldt County

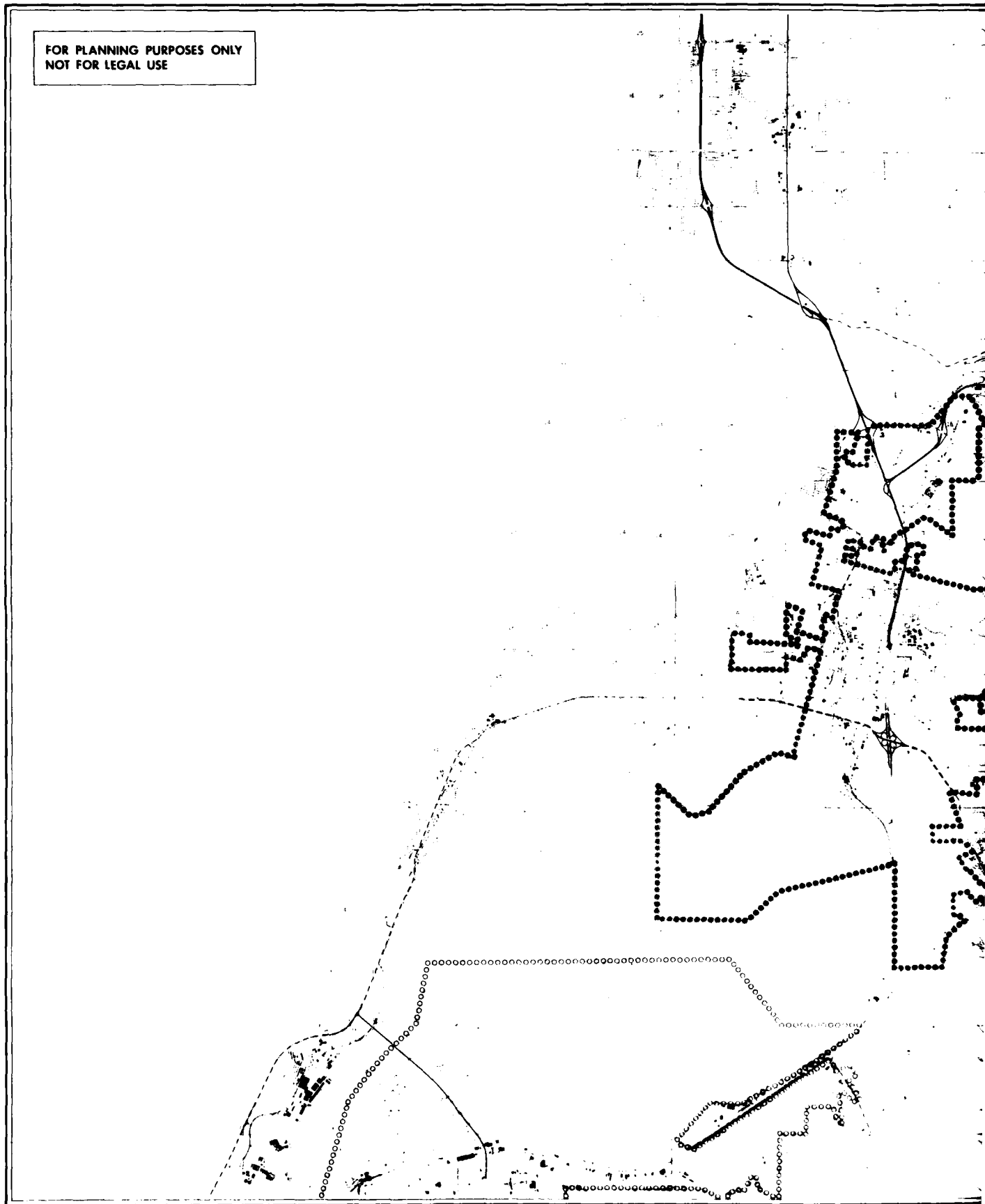
Humboldt County departments with particular interests, activities and policies in the study area include the Planning (in particular the Local Coastal Program section), Public Works, and Public Health.

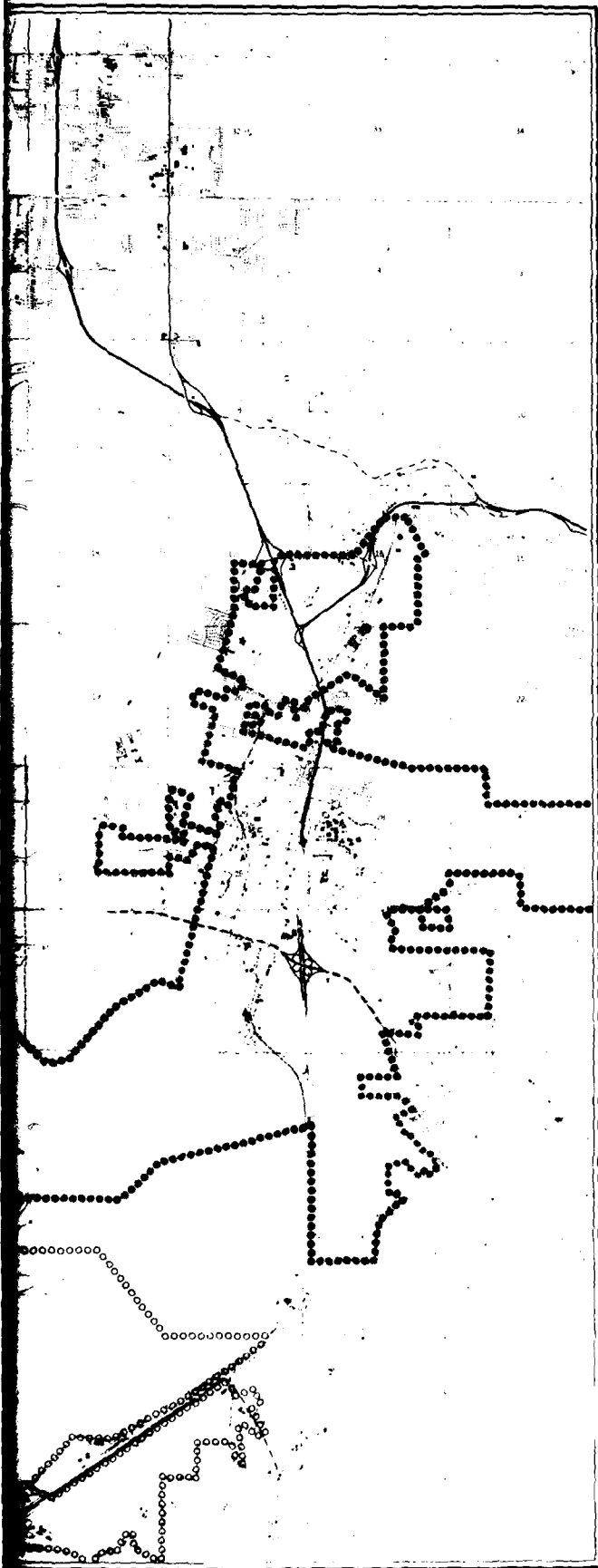
The Humboldt County Planning Department is responsible for the Humboldt County General Plan preparation and revision, county zoning, and the development of the Local Coastal Program.

Humboldt County General Plans. There are several major planning documents which constitute or contribute to the General Plan as it pertains to the Humboldt Bay study area; their status is as follows (Humboldt County Planning Department, 1979, personal communication):

<u>Document</u>	<u>Status</u>
<u>General Plans</u>	
Mid-Humboldt County General Plan 2020 (1971, Baruth and Yoder)	Approved in principle - subject to 'Revisions of Land Use Information Current Census and Other Pertinent Data', 1973.
Humboldt County General Plan: County Wide Objectives and Guidelines, 1976 Hearing Draft (Humboldt County Planning Department)	No actions taken.

FOR PLANNING PURPOSES ONLY
NOT FOR LEGAL USE





CITIES

PLATE NO 17 NORTH

LEGEND

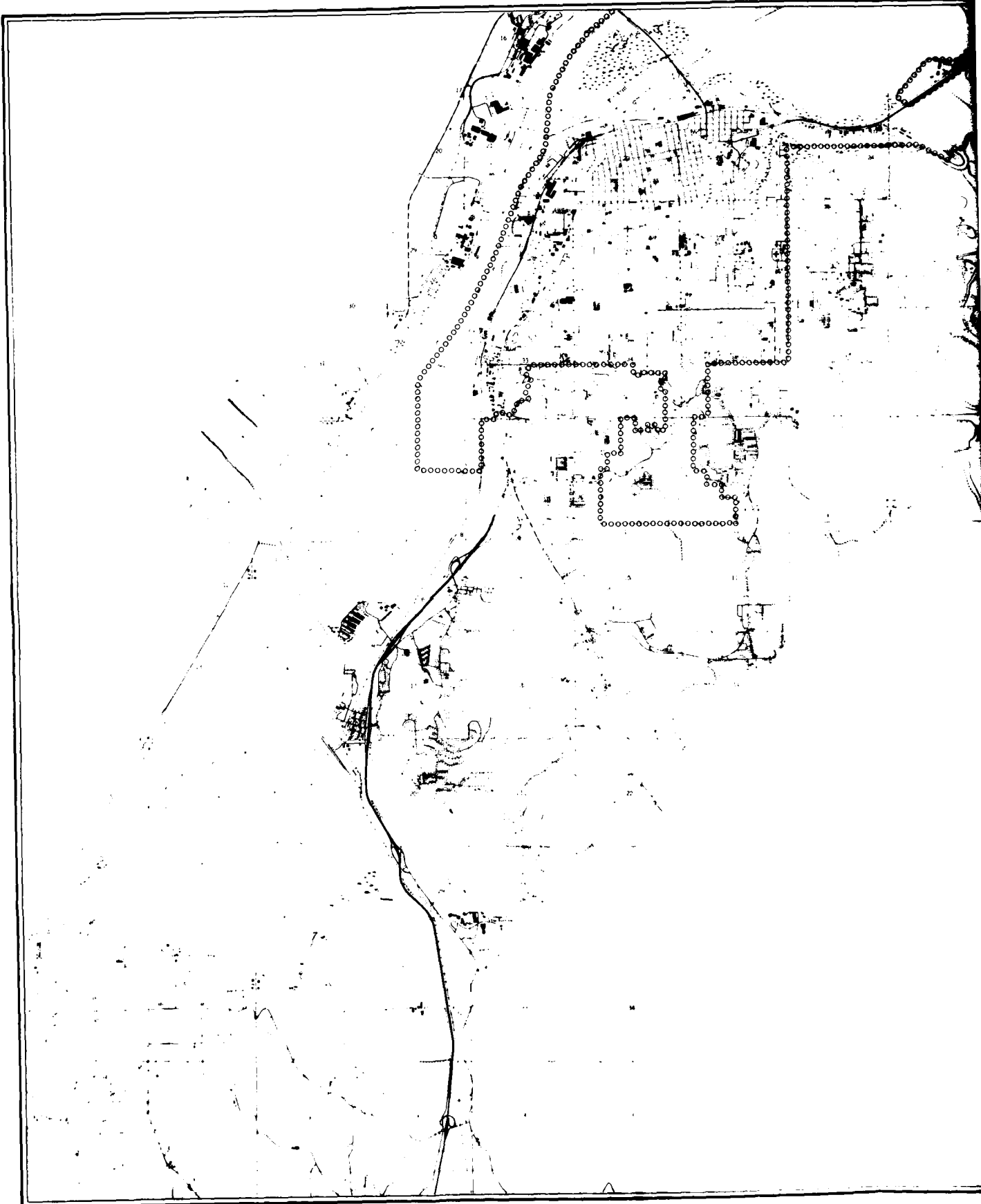
..... Arcata

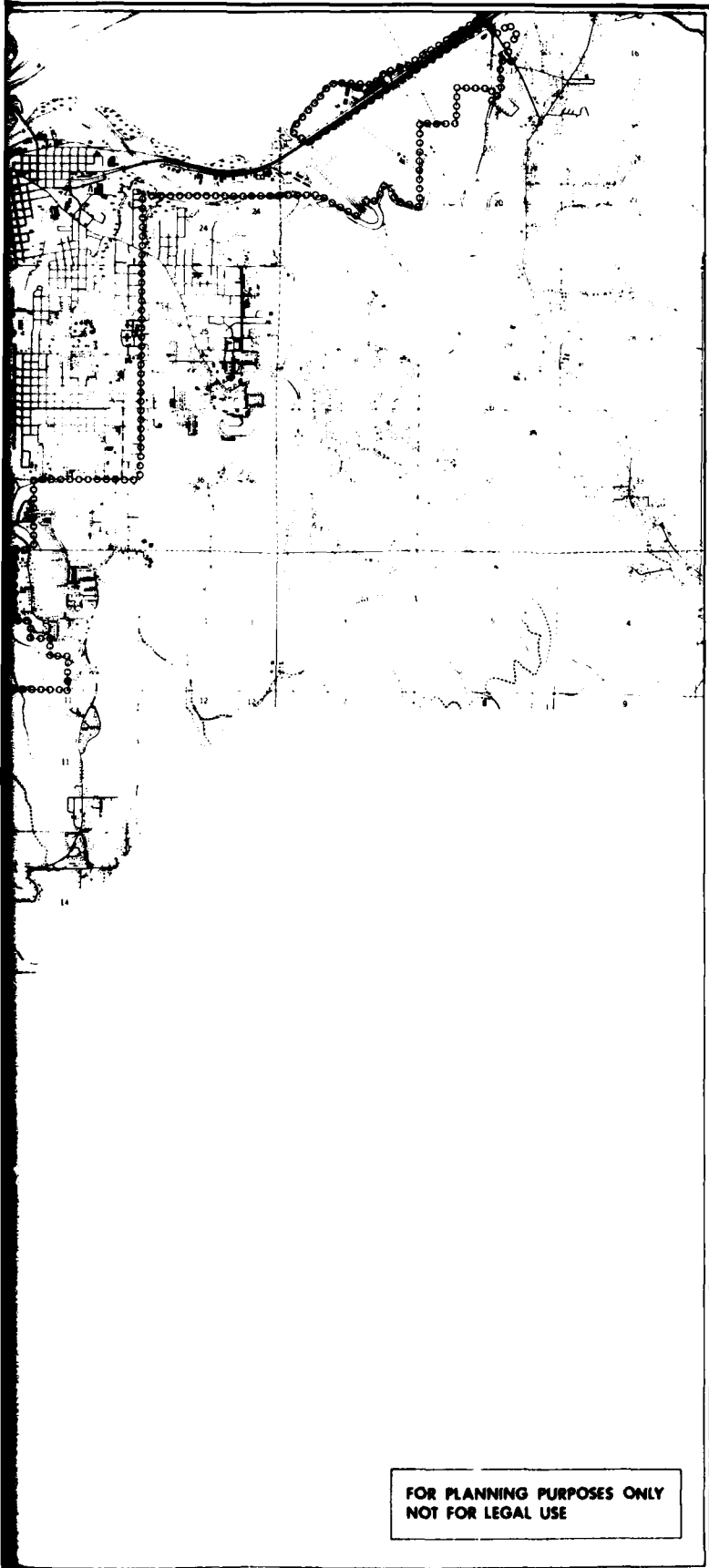
..... Eureka



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: City of Arcata
City of Eureka





CITIES

PLATE NO 17 SOUTH

LEGEND

ooooo Eureka



HUMBOLDT BAY WETLANDS REVIEW
&
BAYLANDS ANALYSIS

Source: City of Arcata
City of Eureka

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General Plan Elements

Housing Element (Humboldt County Planning Department)	Adopted 1978 Res. No. 78-6
Noise Element (Humboldt County Planning Department)	Adopted 1977 Res. No. 77-134
Open Space/Conservation Element (Humboldt County, 1973)	Adopted 1973 Res. No. 73-164
Recreation Element (Humboldt County Planning Department and Humboldt County Department of Parks and Recreation)	Adopted 1976 Res. No. 76-92
Seismic Safety/Public Safety	Published for review 1978

The Mid-Humboldt County General Plan 2020, prepared by Baruth and Yoder in 1971, was a monumental effort sponsored by several Federal and state agencies. This plan includes four reports: a general land use guide, a report on water supply, treatment, and distribution, a report on wastewater collection, treatment, and disposal, and a report on storm drainage (Baruth and Yoder, 1971(1), (2), (3), and (4)). The general land use guide discusses adopted general plans for 1985 in the Humboldt Bay study area (Baruth and Yoder, 1971) and shows a composite projected land use map for 1985. This map projects land use generally as follows:

- . Public and semi-public lands - South Bay and South Spit, Buhne Point, Indian Island, North Spit Coast Guard Station and the ocean beach, North Spit north of the Samoa Bridge and the coastal dunes, the Elk River Spit, and the gulches in the City of Eureka as greenbelts. Indian and Woodley Islands were designated as reserve areas valuable for residential and recreational use.
- . Agricultural lands - the Arcata Bottoms, most of Beatrice Flats, and the Elk River bottom lands. The Bayside - Eureka Slough areas and part of Beatrice Flats appear to be categorized as thick underbrush/timber.
- . Rural residential - the portion of Arcata Bottoms south of Samoa Road with an airport and marina.
- . Industrial lands - the entire area from V Street, Arcata south of Samoa Road and west of Highway 101 with a harbor and shipping channel in the tidelands area. Also, the Eureka-Bucksport strip from Eureka Slough to Elk River, the North Spit south of Samoa Bridge and west of Navy Base Road, and the Fields Landing and PG&E areas.

Baruth and Yoder (1971(1)) projected land use for the year 2020 along these same patterns, with the only major differences being industrial areas along the highway on the North Spit north of the Samoa Bridge, some commercial development in the Bayside, Eureka Slough, and Elk River bottom lands, and a decreased harbor area in Arcata with more public land.

Of the other General Plan elements, the Open Space-Conservation Element (Humboldt County, 1973) is of particular interest (the Recreation element was reviewed for Section VIII-A-3, Recreation). This plan element establishes policies to preserve natural processes, conserve the natural environment, and encourage compatible multiple use of open space lands. Policies of particular interest for the Humboldt Bay study area are listed below:

- . Agricultural lands in flood plains should be retained in agriculture (this includes those areas in the Mad River flood plain - Arcata Bottoms, Class I and II soils).
- . Protection of natural resources. Land and water resources of a unique or unusual character that support endangered species of plant or animal life will be protected. To protect and promote significant wildlife, fish and marine life water areas, development should be prohibited that will have a significant adverse effect upon rivers, creeks, sloughs, estuaries, lagoons, the ocean, marshes, sand dunes and natural floodplains. Significant habitat areas will be protected. (The study area is identified in the plan as marshland fowl and wildlife habitat, a key dependent species survival area, a national wildlife refuge (approved) and a critical water area.)
- . Areas or structures of unique or unusual character will be catalogued and protected. This identification will include a list of Indian historical areas which tribal experts assist in compiling. (See Section VIII-A-1, Archaeology/History.)
- . Protection of health and welfare. Buffer zones may be established near or around certain rivers, creeks, sloughs, estuaries, lagoons, and marshlands to maintain the quality of water and prevent contamination, pollution, or alteration of the quality of water. Public access (visual and physical) to waterways and water-oriented activities will be encouraged when consistent with conservation of the natural processes and private property rights. Other policies deal with visual amenities, noise, development controls, waste disposal, and hazard areas.

Humboldt County Local Coastal Program. Humboldt County's permit jurisdiction in the study area includes all of the lands to

the mean higher high water line (MHHW) except for those in the cities of Arcata and Eureka. The Humboldt Bay Harbor, Recreation, and Conservation District has jurisdiction over submerged and tidelands areas. The Harbor District interprets its jurisdictional limit as extending to the MHHW line. Under the Coastal Act of 1976, only local governments (cities and counties) must prepare a local coastal program (LCP); the Harbor District is exempt from the LCP requirement. However, the Harbor District has passed Ordinance #7 which designates lands and waters of Humboldt Bay for particular uses (see Harbor District under Local Special Agencies below). The exact MHHW line is not known.

The Humboldt County Planning Department, LCP staff, has prepared a detailed work program for LCP preparation in the whole County (Humboldt County, 1978(2)). The County has been divided into LCP planning areas, of which the Humboldt Bay study area (to MHHW) is one. The LCP staff has identified several County-wide key issues and some Humboldt Bay area issues which must be addressed during LCP preparation. The Humboldt Bay area LCP will be completed last in the County's effort; preparation of the draft and public workshops are tentatively scheduled for August/September 1979. Key issues include the formulation of an urban growth policy, agricultural protection, management of environmental resources, preservation of visual resources, and provision of shoreline access (Humboldt County, 1978(2)). Issues specific to the Humboldt Bay area are summarized as follows:

- . Shoreline access - formalizing access points, policy to assure access through new development.
- . Recreation and visitor-facilities - development of designated parks (ocean beaches, Elk River Spit), enforcement of off-road vehicle regulations (this has emerged as a major issue at public workshops).
- . Housing - development and dispersal of low-cost housing.
- . Water and marine resources - protection of riparian habitat and sloughs, protection of water quality.
- . Diking, dredging, filling, shoreline structures - control of dikes and fills, standards for shoreline structures, effects on Bay circulation, identification compensation areas.
- . Commercial fishing and recreational boating - regulation of expanded fishing.
- . Environmentally sensitive habitats - uses of coastal dune forests, protection of wetlands and sloughs.

- . Agriculture - zoning and protection of agricultural lands and viability, conversion of agricultural lands, buffer areas, tax assessments.
- . Hazards - potential areas.
- . Forestry - Timber preserve zone (TPZ) areas near Ryan Slough and Elk River valley.
- . Location of new development - infilling, park requirements, planning and zoning, protection of archaeological/historical resources.
- . Visual resources and special communities - control of billboards, protection of open space views, impacts of industrial development.
- . Public works - formulation of sewer hook-up restriction policies, road capacity south of Ryan Slough.
- . Industry and energy - priority for coastal-dependent industry, control of OCS development, location of oil storage facilities, minimizing impacts on wetlands, areas designated unsuitable for power plants.

As part of the LCP effort, in June 1978 Humboldt County established the Humboldt County Coastal Advisory Committee (CAC), officially charged with recommending coastal plans for the six planning areas. The LCP staff is preparing technical reports on coastal land use and resources; the CAC is reviewing these reports and making recommendations and policies to be part of the final coastal plans. Technical reports cover visual resources, recreational demand, water quality, urban services, housing, habitat sensitivity, access, timberland, commercial beach use, agriculture, industrial siting, and archaeology (Coastlines, October 1978). CAC recommendations to date are summarized below:

- . Visual resources. The CAC recommends that billboards be "prohibited in viewshed areas; such designations will come from maps in the Visual Resources Protection Report but will be subject to later revision by the CAC." Design review is the CAC preferred option for visual resource protection. (Coastlines, November 1978)
- . Recreational demand. The CAC agreed on a 100% increase in demand for private recreation opportunities between 1980 and 1990 and recommended 115 acres for additional private recreation facilities in the Humboldt Bay area. The CAC expressed concern for providing off-road motorcycle facilities and ball parks and made some specific recommendations. (Coastlines, December, 1978)

- . Urban services. The CAC recommended maintaining options for provision of services to development and discussed establishment of urban reserves on the fringes of developed areas. (Coastlines, December 1978.) The CAC also held workshops on commercial beach use (split making, burl slabs, and beach fishing).
- . Access. The CAC called for a policy to minimize County expenditures for acquisition and maintenance of accessways and was concerned about liability limits for property owners. The CAC wants evaluation of impacts of access on existing or proposed property uses, stressed negative impacts of access on agriculture and endorsed the coastal trail concept. (Coastlines, January 1979)
- . Water quality. The CAC classified Jacoby Creek and Ryan Creek as Category A streams, those requiring minimum stream flows most urgently because of the importance of fish habitat and adjacent development pressure. The CAC adopted a policy on groundwater withdrawals from the North Spit requiring demonstration that such withdrawals not degrade dune vegetation or significantly induce salt water intrusion. The CAC discussed criteria for minimum lot size in unsewered areas and passed a policy that sewage disposal systems on existing lots meet health department requirements. (Coastlines, January 1979)
- . Housing. The CAC approved three options to encourage lower cost housing: self-help housing (a low cost loan program to low income families to bring homes up to code); mobile home and multiple unit zoning (prezoning of appropriate parcels) and the housing development corporation (to stimulate housing development by providing technical information and locating low-cost funds). (Coastlines, February 1979)
- . Timber. The CAC defined Coastal Commercial Timberland as all land in the Coastal Zone of Humboldt County which is included in the TPZ plus coastal lands 40 acres and larger on lists A and B at the County Assessor's office. The CAC adopted a list of nine land uses compatible with timber production in the TPZ and limited compatible uses involving conversion of TPZ land (e.g., houses or power facilities) to 5% of the total parcel to a maximum of 2 acres for a home site. The CAC voted to maintain the present minimum for subdivision of TPZ (40 acres for a joint timber management plan and to allow list C applications at 20 acres and larger with a single owner). (Coastlines, February 1979)

- . Agriculture. The CAC decided on land uses compatible with agriculture, using the input from public workshops in January. Compatible uses include dog ownership, houses (more than one per parcel), radio/TV transmission facilities, hog farms (use permit required adjacent to residential uses), and greenhouses (no concrete slab floors allowed over prime soil). The CAC will need to consider other technical reports in determining urban limit lines. (Coastline, March 1979) The CAC approved two minimum parcel motions, one for prime land (SCS Class I and II, Storey index 80+, supporting one cow or five sheep per acre, or net yield of \$200/acre) and one for non-prime land south of Centerville. For prime lands, the motion is "An Agriculture Exclusive Zone (see Zoning below) for prime lands be established with a minimum parcel size of 60 acres but allowing divisions to 20 acres on lands under the Williamson Act." Non-prime lands in the study area will be considered under a philosophy of minimum parcels large enough to assure continued viability as agricultural land. (Coastlines, April 1979.)
- . Habitat. The CAC approved performance standards for removal of riparian vegetation, distinguishing between perennial and ephemeral streams and between residential and agricultural-open space areas. (Specific habitat recommendations for the Humboldt Bay area await the results of this Corps study.) (Coastlines, March 1979)

In June 1979, a draft of Coastal Land Use Policies and Standards for Humboldt County was issued (Humboldt County LCP, 1979(a)). This document in its final form will be one of the components of the completed Humboldt County LCP. The other three components are: (1) area plans for the six coastal planning areas of the County, (2) zoning ordinances and maps for the six areas, and (3) implementing actions. The Coastal Land Use Policies and Standards will provide general land use and development guidelines for the coastal zone. It contains policies and standards for urban and rural development, resource protection, and access. Of particular interest are the policies on wetland buffer areas and riparian corridors, defined as follows:

Other than in wet pasture lands, no land use or development shall be permitted in areas adjacent to coastal wetlands, called Wetland Buffer Areas, which degrade the wetland or detract from the natural resource value, but will incorporate such features into the development site design.* Wetland Buffer Areas shall be defined as:

* Note: This policy statement was being revised as of October 1979 (Patty Dunn, Humboldt County Local Coastal Program, personal communication).

- a. The area between a wetland and the nearest paved road or the 50 foot contour line (as determined from the 7.5' USGS contour maps), whichever is the shortest distance, or
- b. 450 feet from the wetland, where the nearest paved road or 50 foot contour exceeds this distance.

With the exception of the Eel River Planning Area, and removal of riparian vegetation associated with timber harvesting activities, riparian corridors shall be defined as follows:

- a. 100 feet, measured as the horizontal distance from the edge of the water course (mean rainy season), on either side of perennial streams.
- b. 50 feet, measured as the horizontal distance from the edge of the water course (mean rainy season), on either side of ephemeral streams.

The Humboldt County Department of Public Works is responsible for public works projects in the County. The Department handles sewer service (County Service Area #3, see below), road systems and maintenance, permits, property management, and flood control projects. The Natural Resources Division of Humboldt County Public Works prepares technical resources studies and environmental documents for public works construction projects. The division also houses the County Environmental Data Base with an extensive collection of historic maps, aerial photographs, and natural resources data, which was made available by Mr. Don Tuttle during the course of this study. The Natural Resources Division is also responsible for Solid Waste Management. The County operated a landfill at Table Bluff until May 1979, when it was ordered closed by the North Coast Regional Water Quality Control Board because of leachate contamination to Humboldt Bay. Solid waste is currently transferred from a container collection system by franchised collectors to the Humboldt Transfer and Recycling Center in Eureka. Compacted solid waste is then transferred to a landfill at the end of Cummings Road outside of the study area.

The Humboldt County Health Department has numerous functions; of most interest for this study is the Health Department's role in controlling individual waste treatment and disposal systems in the study area. The Health Department enforces Section 18 of Ordinance 945, Sewage Disposal Regulation, inspects existing and proposed individual systems, and reviews water supply and sanitation provisions for major subdivision proposals. Specific practices in Humboldt County and the North Coast Region have been reviewed by the Regional Water Quality Control Board (Hantzsche and Wistrom, 1978).

City of Arcata

In the city of Arcata, the City of Arcata Planning Department is responsible for preparation and revision of the Arcata General Plan and for the Local Coastal Program effort. The Planning Department is also the environmental review coordinator for the city. Of particular interest for this study are the Arcata General Plan and the LCP documents, as they represent statements of City policy and plans for future development.

Arcata General Plan. The Arcata General Plan, adopted in 1975, is a composite of policies, programs, and intended actions to govern the future (20 year) physical development of the City of Arcata and its planning area (City of Arcata, 1975). Arcata's planning area is bordered by the Pacific Ocean on the west, the Mad River on the north, Fickle Hill Ridge on the east, and by Jacoby Creek and a line running through Arcata Bay, roughly parallel to Bayside Cut-off, on the south. The General Plan maps land use in six major categories and indicates areas appropriate for their development over the next 20 years; the categories include residential, commercial, industrial, public, parks and open space, and rural (agricultural and forest/hillsides). The land uses as outlined on the General Plan map should be the basis on which zoning districts should be established. The General Plan shows the entire Arcata Bottoms area outside the city limits as agricultural or natural resource/wildlife habitat except for two small industrial areas at the Mad River Slough north of Samoa Road Bridge, an industrial park area south of 27th Street, and a small residential area at Janes and Upper Bay Road. In the Bayside Bottoms, virtually the entire area between Highway 101 and Old Arcata Road is shown as agriculture; there are small residential patches along Old Arcata Road. The agriculture designation allows some residential development. Industrial development is concentrated in the following areas (1) south of Samoa Boulevard between Highway 101 and I Street; (2) between Q Street (extended) and I Street north and south of Samoa Boulevard; (3) north of Samoa Boulevard between V Street and McDaniel Slough; (4) in the area south of 27th Street; and (5) in the northeast part of the planning area along Arlington Way. Urban expansion areas are generally contiguous to existing development. Park areas are shown along McDaniel Slough and around the area proposed for the marsh reclamation project (Plate 22). A strip of natural resource/wildlife habitat borders the tidal flats.

The General Plan contains general and specific policies which are reflected on the General Plan map and recommendations for implementation of these policies. The most pertinent policies for this study are summarized below; numbers are from the General Plan:

- I-1 The designation of areas for new urban development should reflect physical features and natural characteristics. Flood prone areas are not suit-

able for most types of urban development. Hillside and forested areas are suitable only for very low density development. Agriculturally suitable areas are not appropriate for urban development, with the exception of designated areas contiguous to existing urban uses.

- I-2 Greenbelts of agricultural use should be preserved adjacent to urban development and should also be used to separate different portions of the urban area.
- II-1 Land should be used for the purpose for which it is most suited by virtue of its inherent natural characteristics, as modified by its locational relationships.
- II-2 The policies of Arcata's adopted Conservation Element, dealing with conservation of natural resources, should be followed: Areas over 25% slope should generally be conserved in a natural condition. Agriculturally suitable land should be preserved for agricultural use, wherever possible. Flood-prone areas should be used for agricultural and recreational purposes and kept free from urban development wherever possible. Rivers, streams and adjacent areas, and marshes should remain in a natural condition. Unique vegetation and wildlife areas should generally remain in a natural condition. Such areas include the sand dunes and backdune woodland, eel grass area, salt marshes, and special habitat areas (tern and osprey nesting areas, cormorant rookery, harbor seal area and egret roost).
- III-3 In order to preserve natural resources, to conserve agricultural land, to provide recreational opportunities, and to protect wildlife habitat areas, the following areas should be preserved as open space, free of urban uses:
 - . Natural resource land: ocean beach, sand dunes, backdune woodland, Arcata Bay, Mad River, Mad River Slough and portions of the coastal forest characterized by steep slopes and subject to geologic hazards.
 - . Agricultural land: agriculturally suitable areas (see Chapter I, Policy 1).

- . Recreational land: neighborhood and community parks, Baywood golf-course, and buffer strips along the Mad River, Janes Creek, Jacoby Creek, Jolly Giant Creek, Beef Creek, and Campbell Creek.
- . Wildlife habitat: salt marsh, eel grass, and special habitat areas.

II-4 The City should officially designate agricultural preserves, pursuant to the Williamson Act, for the purpose of entering into contracts with land owners within these preserves.

Other Arcata policies deal with public and seismic safety, noise, energy and food production, industrial and commercial economy, residential development, public services (including parks and recreation and visual amenities). Implementation mechanisms involve zoning, land acquisition, adoption and enforcement ordinances, development of studies and new programs, and new public works projects.

Arcata Local Coastal Program.* The Arcata LCP effort is well underway and the Arcata Local Coastal Plan is expected to be drafted by September-October 1979 (Ray, 1979, personal communication). The City issued a final draft of the LCP Work Program in July 1978 (City of Arcata, 1978), identifying coastal planning issues for the City and its planning area; the Coastal Commission reviewed the LCP work program and added two issues (CCNCR, 1978). The Arcata coastal planning issues are summarized below (City of Arcata, 1978); (CC) indicates an issue added by the Coastal Commission:

ISSUES WITHIN ARCATA CITY LIMITS

Shoreline Access. Use level the ecosystem of the tidal marsh land can sustain, and location of access points.

Recreation and Visitor Serving Facilities. Type of desirable recreational and visitor serving developments in north Arcata Bay, and design level of use.

Housing. Extent of housing opportunities for low and moderate income people in the City's coastal zone. (CC) Policies needed to protect existing low and moderate cost housing and to provide new low cost housing in the coastal zone.

*The Arcata Local Coastal Plan has been issued (June 1980).

Water and Marine Resources, Environmentally Sensitive Areas. Aggravation of siltation problems and the loss of riparian habitat by development along creeks. Type of maintenance program causing the least disturbance to fish and wildlife values.

Diking, Dredging, Filling, and Shoreline Structures. Need to comply with Coastal Act policies.

Commercial Fishing and Recreational Boating. Policies to encourage and protect aquaculture in the Bay.

Agriculture. Minimum lot size and policies to preserve agricultural lands as defined in the Coastal Act. Recreational use of agricultural land and its consistency with Coastal Act policies.

Hazard Area. Adequacy of Seismic Safety Element policies and standards. Need to protect existing businesses in the flood-prone land around south "G" Street.

Locating and Planning New Development. Location of the rural/urban boundary.

Coastal Visual Resources and Special Communities. Preservation of the City viewshed.

Public Works. Flood control measures and possible damage to natural environmental values in the creek habitat. Consistency of the proposed Arcata Wastewater Reclamation and Aquaculture project with the Coastal Act policies regarding public works. Impacts of removing the McDaniel Slough tide gates and constructing dikes to allow tidal action; flooding problems elsewhere by the waters diverted by the dikes. Effects on the wildlife habitat of the section of the Slough involved. Consistency of the Arcata Corporation Yard with Coastal Act goals and future expansion at that site.

Industrial Development and Energy Facilities. Types of industrial uses compatible with coastal policies regarding coastal visual resources, adjacent natural areas, hazards, and other Coastal Act concerns. (CC) Suitability of designated industrial areas for compatible types of industrial development.

ISSUES OUTSIDE ARCATA CITY LIMITS

Arcata Bottoms and East Bay Areas. Consistency between city and county zoning of agricultural lands. Possible need for floodplain zoning on all unincorporated land within the 100 year flood zone in the planning area. Appropriate location for the urban/rural boundary in the Arcata planning area and appropriate rural land division criteria for rural lands in the city and surrounding area.

Industrial/Urban Expansion Lands. There are three areas of concern: the undeveloped area north of Greenview subdivision and west of Janes Road designated as an urban expansion area, presumably to allow for additional housing; the old mill site east of "V" Street and north of Samoa Boulevard is designated as industrial; the area along South "I" Street between the Bay and Samoa Boulevard is designated as industrial. The major issue involving these unincorporated areas is whether or not the land use designations are consistent with Coastal Act policy.

COASTAL AREAS OF GREATER THAN LOCAL IMPORTANCE

Wildlife Habitats. Arcata Bay and mud flats; Bay marshes and associated pasture lands; Humboldt Bay Wildlife Refuge.

Agricultural Areas. Arcata Bottoms, East Bay tidal plain.

Transportation Corridors. U.S. Highway 101

The schedule for completion of Arcata's LCP is set for approximately September 1979 for a draft plan to be submitted for formal review (Butler, 1979, personal communication). Technical reports on the various issue points have been prepared; they cover shoreline access, hazard areas, agriculture, water and marine resources, coastal visual resources and special communities, commercial fishing and recreational boating, recreation and visitor serving facilities, housing, industrial development, public works, and diking, dredging, filling and shoreline structures (City of Arcata LCP, 1979, (1)-(11)). The access report is discussed in Section VIII.A.3, Recreation. The report on coastal visual resources and special communities is discussion in Section VIII.B, Aesthetics. Aspects of commercial fishing and recreational boating are discussed in Sections VIII.C, Economics, and VIII.A.3, Recreation. Principal information points from the others are summarized below; recommendations and proposed policies are not discussed here because the Plan itself will soon be available:

Hazard Areas: Geology. Liquefaction is the major seismic hazard in the Arcata area. The following public and private critical facilities in the Coastal Zone are presently located in an area of high liquefaction potential.

1. The City of Arcata's Corporation Yard and Sewage Disposal Facility
2. California Highway Patrol Office
3. U.S. Highway 101 and the Samoa Boulevard overpass
4. Bloomfield School, Jacoby Creek School, St. Mary's School, and Equinox School
5. Humboldt Bay Municipal Water District, Water Main
6. Radio Station KATA

Hazard Areas: Floods. Flooding is a major hazard in agricultural areas and some industrial and residential areas in Arcata. The area along South G Street and in the southern portion of the Q Street to Buttermilk Lane part of the coastal zone is subject to flooding. The City has minimized development in the flood zone and has applied a flood control overlay zone in some areas.

Agriculture. All of the 800 acres of agricultural land within Arcata City limits and the Coastal Zone is zoned Agricultural-Exclusive (see Zoning below) with a minimum parcel size of 20 acres, except a small area of Residential-Agricultural. The Arcata Bottoms area in the County is Agricultural-Exclusive, as is the East Bay Plain. Certain recreational activities, including hunting, wildlife observation, and playing fields, occur in the agricultural area.

Water and Marine Resources. The report identifies stream channels (Jacoby, Jolly Giant, and Janes Creeks) and sensitive habitats (tidal flats and marshlands) in Arcata. Jacoby Creek is important fish habitat in fair condition. Jolly Giant Creek is severely degraded and in poor condition. Janes Creek is blocked to fish by a tidal gate at McDaniel Slough and is in poor to fair condition. The North Arcata Bay tidelands are designated wildlife conservation in the Arcata General Plan. Salt marsh is a valuable habitat; on the Bay's north shore, the scattered marshes total about 100 acres. The report reviews maintenance programs and land use around the streams and marshlands.

Recreation and Visitor-Serving Facilities. These facilities in Arcata's coastal zone include the Jacoby Creek unit of the Humboldt Bay Wildlife Refuge, the Arcata Boat Basin, the wastewater treatment plant oxidation pond and landfill site, facilities at St. Mary's and Bloomfield elementary schools, and various nonrecreation-oriented businesses along Samoa Boulevard and 7th Street. The City proposes three parks: the Arcata Community Park in the 30-acre area bounded by 7th Street, Highway 101, Samoa Boulevard, and Union Street; the McDaniel Slough Linear Park, a passive use greenbelt; and the Greenview Park. Arcata has received approval and funds to carry out the Arcata Marsh Enhancement project on 63 acres in the landfill and boat ramp area, and the Humboldt County Trails Plan shows a route through Arcata called the Bayview Levee Trail, following dikes around the edge of Arcata Bay (See Plate 22 and Section VIII.A.3, Recreation).

Housing. In the Arcata city limits and the coastal zone, there are 138 single family houses, 566 multifamily units, and several areas of vacant land where housing construction could be done. Single family dwellings are concentrated in the 20-block area bounded by 7th Street, Samoa Boulevard, F Street, and K Street, and south of Samoa Boulevard along F, G, and H Streets. Multifamily housing is mostly found in the new apartment complexes between 7th Street and Samoa Boulevard and south of Samoa Boulevard along G and H Streets. Housing costs and rental rates in the coastal zone are generally comparable to and on a par with those throughout the city.

Industrial Development. Industrial areas include the corridor from South G Street north to 16th Street (about 238 acres in the coastal zone) and a 22-acre area at the intersection of V Street and Samoa Boulevard. Most of the industries are forestry-related. There are about 75 acres of undeveloped, industrially-zoned land in the coastal zone. Rezoning of about 25.8 acres of land zoned for industrial and agricultural uses in the vicinity of I Street and the Northwest Pacific Railroad tracks is being considered in conjunction with the marsh enhancement project. None of the existing industrial uses is coastal-dependent.

Public Works. Flood control dikes exist along the perimeter of the Bay and the banks of Janes Creek/McDaniel Slough, Gannon Slough, and Jacoby Creek. Janes Creek along 11th Street and all of Jolly Giant Creek are dredged. Proposed new flood control projects include enlarging tide gates on

McDaniel Slough to reduce seasonal flooding and dredging presently undredged stretches of creek (e.g., the lower reaches of McDaniel Slough). The Arcata Marsh enhancement project is discussed in Section VIII.A.3, Recreation. Arcata's sewage treatment plant at the oxidation pond provides secondary treatment with an outfall to Arcata Bay. The City's corporation yard on the Bay shore at the south end of G Street (housing City equipment and public works departments) is about 30 acres, about half of which is developed.

Diking, Dredging, Filling, and Shoreline Structures. In addition to dikes and dredging described above, Arcata will construct 3,100 linear feet of dike and will move almost 50,000 cubic yards of earth in connection with the marsh enhancement project. Dikes along Gannon Slough and Jacoby Creek are not presently maintained. Shoreline structures include tide gates on McDaniel, Butcher, and Gannon Sloughs and the Arcata Boat Ramp.

The City of Arcata Department of Public Works has responsibility for public services in the City, including sewer and water service, road construction and maintenance, development of a Capital Improvement Program, and other public works functions. A public works project of particular interest for the Humboldt Bay study is Arcata's proposed Wastewater Treatment, Water Reclamation and Ocean Ranching project (City of Arcata, 1977 (1)).

Arcata began to study wastewater management in 1973, contracting for a project report for a wastewater management plan. This plan was felt to be contrary to Arcata's best interests; although Arcata was shown to have an adequate sewage treatment plant, the report recommended abandoning the Arcata plant and locating a central treatment plant in Eureka (City of Arcata, 1977 (2)). Arcata reluctantly became a member of the Humboldt Bay Wastewater Authority (HBWA, an agency formed to design, construct, and operate a regional sewage system) only after the adoption by the SWRCB of the Bays and Estuaries Policy prohibiting any discharges to the Bay unless enhancement of Bay waters could be shown. (City of Arcata, 1977 (2)). Arcata has remained a reluctant member of HBWA, and many Arcata citizens and other residents of the area oppose the regional system (Stratford, 1979, personal communication; Bertain, 1979, personal communication).

In 1977 the Arcata Director of Public Works undertook to try to prove enhancement of Bay waters with the pilot aquaculture project in Arcata's oxidation pond (City of Arcata, 1977 (2)). Arcata is proposing an alternative method of wastewater treatment,

which the City believes would result in discharges enhancing Bay waters. Thus, Arcata's discharges would meet the Bays and Estuaries policy, and Arcata could relinquish its HBWA membership. The City's proposal is as follows.

The City of Arcata's sewage treatment facility is located on the Bay shore. The treatment plant presently provides secondary treatment with Bay discharge. The City is proposing to modify its facility to create an innovative wastewater reclamation project which would provide tertiary treatment, combined with ocean ranching as a use and reclamation of wastewater. The project would involve processing sewage through an improved processing system, and extended oxidation period, a freshwater marsh, and a recreation lake. A fish hatchery for salmon and trout would be integrated into the treatment facility.

The City of Arcata believes that the Arcata Wastewater Treatment, Water Reclamation, and Ocean Ranching Project would be of importance to the entire Humboldt Bay area when built. The City feels the project would result in a significant increase in salmon and trout runs through the creeks surrounding north Humboldt Bay and the creation of the freshwater marsh will have regional significance (City of Arcata, 1978). Arcata applied to the State Coastal Conservancy for funding for this project. Although the Coastal Conservancy did not grant such funds, the agency did provide support for the marsh creation portion separate from the wastewater treatment part (see Section VIII.A.3, Recreation, and discussion of the State Coastal Conservancy above). The SWRCB feels that Arcata's project may enhance Humboldt Bay water quality.

City of Eureka

The City of Eureka Department of Community Development is responsible for preparation and revision of the Eureka General Plan and the Eureka Local Coastal Program, both of which provide policy direction for development and the review of proposed projects.

Eureka General Plan. The City of Eureka adopted its initial General Plan in 1965. In 1977 Eureka finished a complete revision and update of the 1965 General Plan, partly in response to new state planning laws. The 1977 General Plan consists of a general plan policy document and 13 technical background reports on elements such as land use, natural resources and open space, noise, and waterfront. The General Plan was formulated with public participation and is an expression of policy guidelines for development in Eureka.

The Eureka General Plan covers the City and its planning area, which includes the Elk River area and the North Spit from Samoa Bridge to south of Fairhaven. The horizon year for the Plan is 1995 (City of Eureka, 1977(1)).

The General Plan shows agricultural, forest, and open space areas in the Eureka Slough area except for commercial use along the north side of the Slough adjacent to Highway 101. The Elk River Spit and areas south and east of the City limits are also shown as agriculture-forest-open space, with residential areas as extensions or infilling of established residential areas. The Plan shows industrial use along the Bay shore west of 101 from approximately the Eureka Boat Basin to the south city limits; most of the North Spit west of Navy Base Road from Samoa Bridge to the Samoa boat ramp is also designated for industry. The City waterfront west and north of Highway 101 is commercial; the City has a very specific plan for the waterfront/tidelands portion of this area, showing street vacations and circulation improvements, view corridors and vista points, parks, public access, commercial/office development, and basic employment (City of Eureka, 1976-77(1)). Eureka also has a specific Core Area Development Plan (City of Eureka, 1973(1)) for the center city area. The Islands (Indian, Woodley, and Daby) are all agriculture-forest-open space, together with the entire east Bay shore west of 101 (except for the industrial Brainard and Bracut sites. The City has significant existing Greenway acres along Martin Slough and the gulches (City of Eureka, 1976-77(2)); the General Plan proposes a Formal Gulch Greenway system coordinating the gulches, waterfront, active recreational areas and passive open space surrounding the City. Nine new neighborhood parks and seven waterfront plazas are proposed.

Eureka General Plan policies of particular importance include the following (City of Eureka, 1977(1)):

- . The full complement of urban utilities should not be made available to areas not designated for development (agricultural areas, forest areas, unsuitable slopes).
- . Prime industrial land should be protected from encroachment by non-industrial uses.
- . Uses dependent on waterfront locations should receive support for sites along industrially designated lands of Humboldt Bay.
- . Critical habitat areas include eelgrass beds, mudflats, coastal salt marsh and freshwater marsh (City of Eureka, 1976-77(2)), located primarily in Humboldt Bay, on the

Islands, and on the marshy areas around Eureka Slough. The City should protect critical habitat areas and preserve the ecosystem of existing natural areas within the Eureka area.

- . The City should allow for selective development of major open-space areas around and within the City to allow for needed development yet continue to preserve vital portions of these open-space areas in their natural state in order to ensure their maintenance as wildlife and fish habitat areas, natural drainage areas, agricultural areas and areas of passive recreation and outdoor education.
- . The City should retain economically viable and prime agricultural land in its present state as a land use priority.
- . The City should discourage any filling of Humboldt Bay.
- . Public access to the waterfront should be protected, encouraged, and, where possible, provided, including visitor, recreational and housing opportunities for persons of low and moderate income.
- . Coastal recreation facilities should have priority over private residential, general industrial and general commercial development but not over agriculture or coastal-dependent industry.
- . Marine resources should be maintained, enhanced, and where feasible, restored, including facilities serving commercial and recreational boating.
- . Sensitive coastal habitat areas should be protected.
- . Prime agricultural land should be encouraged to remain in agricultural production.
- . New waterfront development should be located within or in close proximity to existing developed areas.
- . The scenic and visual qualities of the coast should be protected.
- . Coastal dependent industrial facilities should be encouraged to locate or expand within existing sites.
- . Coastal dependent developments should have priority over other types of waterfront development.

- . Wherever feasible, public facilities should be distributed throughout the coastal area.

According to Jack Segal (Segal, 1979, personal communication), the Coastal Commission, North Coast Region (CCNCR) does not think that the General Plan or the waterfront plan will meet the Coastal Commission standards for certification.

Eureka Local Coastal Program. The City of Eureka prepared an LCP issues identification and work program in 1977 (City of Eureka, 1977); it was reviewed but not approved by the CCNCR. The CCNCR staff identified other issues which they felt should be addressed in Eureka's LCP, but Eureka did not agree. According to Jack Segal (Segal, 1979, personal communication) Eureka and the CCNCR have a difference in philosophy; Eureka is trying to use as much land as possible, while the CCNCR is interested in preserving land as open space. Eureka has relinquished the responsibility for preparation of the City's Local Coastal Program to the CCNCR (Segal, 1979, personal communication; D'Amico, 1978, personal communication).

The issues identification report prepared by Eureka (City of Eureka, 1977(2)) still represents the City's views (Segal, 1979, personal communication); its identified key issues are summarized following:

- . Environmentally Sensitive Habitat Areas. According to Eureka's General Plan, "The City should protect critical habitat areas and preserve the ecosystem of existing natural areas." What analyses need to be undertaken in order to develop site-specific zoning and EIR policies for the protection of these critical habitats?

Factors to consider: Site characteristics; definition of critical habitats; acceptable mitigation practices; appropriate plans, policies and implementing tools consistent with State and local concerns.

- . Agriculture. What implementation measures, if any, are necessary in order to provide adequate definition and reasonable assurance of stable boundaries for the City's prime agricultural land?
- . Locating and Planning New Development. The "East Bridge District" is generally that part of Eureka east of the Samoa Bridge approach and south of the rail line. In this area, what implementation action should be taken to provide an appropriate mix of commercial, industrial and residential uses?

*In June 1980, the California Coastal Commission issued a draft Issue Identification/Work Program for the Eureka LCP.

Factors to consider: General Plan's "Commercial-Residential" designation; existing and imminent non-conforming uses and structures; historical character; protection of and provision for low-and moderate-income housing; existing physical access constraints; proposed zoning ordinance; public facilities; Eureka's Housing Element.

- . Industrial and Energy Development. Eureka's developable industrial land resources are very limited. The General Plan proposed industrial and service-commercial uses for the area generally between Broadway and the western waterfront. How can this land be used most efficiently and effectively while complying with the intentions of the Coastal Act?

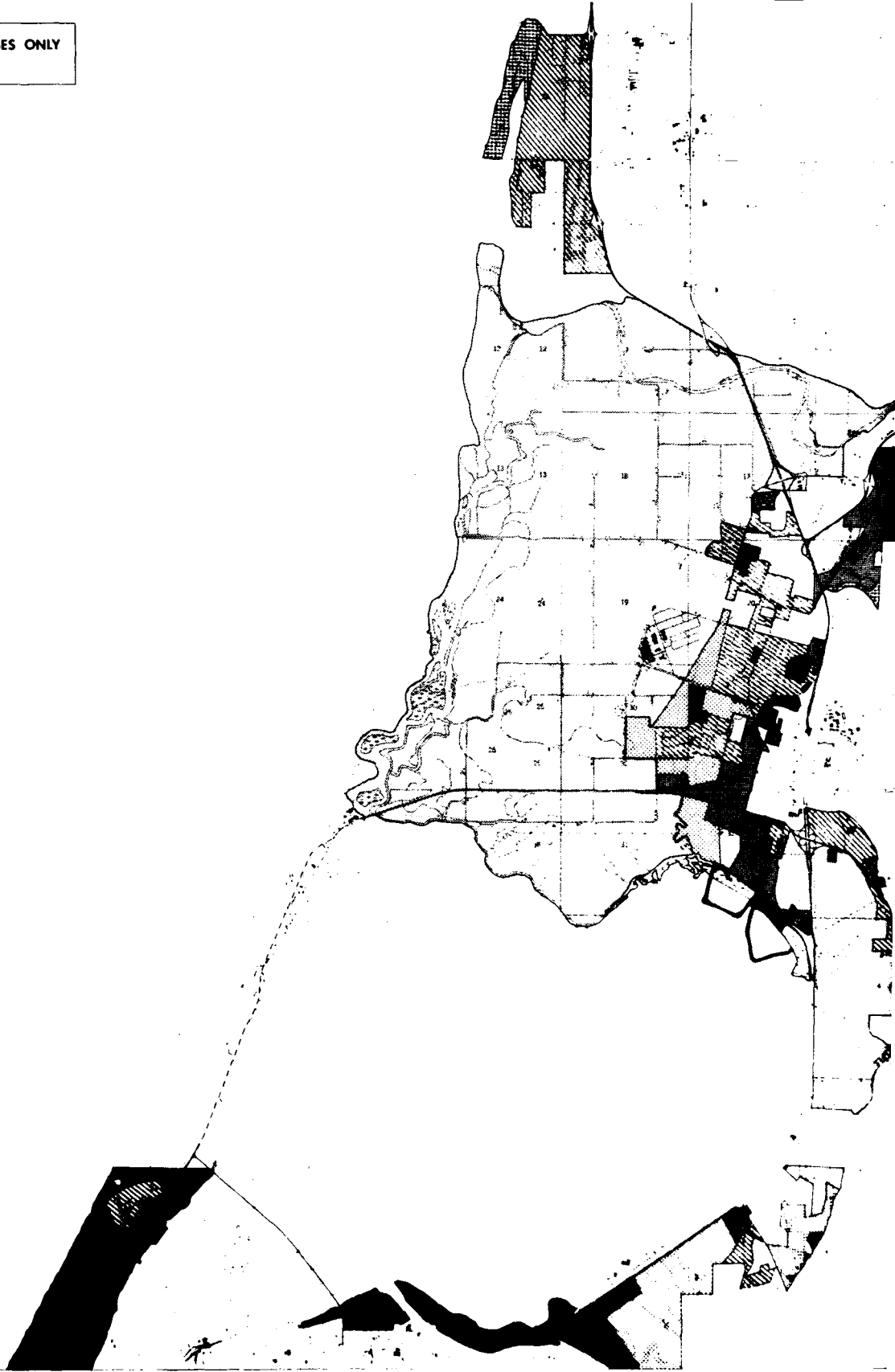
Factors to Consider: Coastal-dependent and non-coastal-dependent land and facility needs; existing provisions for public access and recreation; analysis of alternative interim measures for access, given the delay in implementation of the freeway construction; possibility of port facility consolidation; hazards prevention.

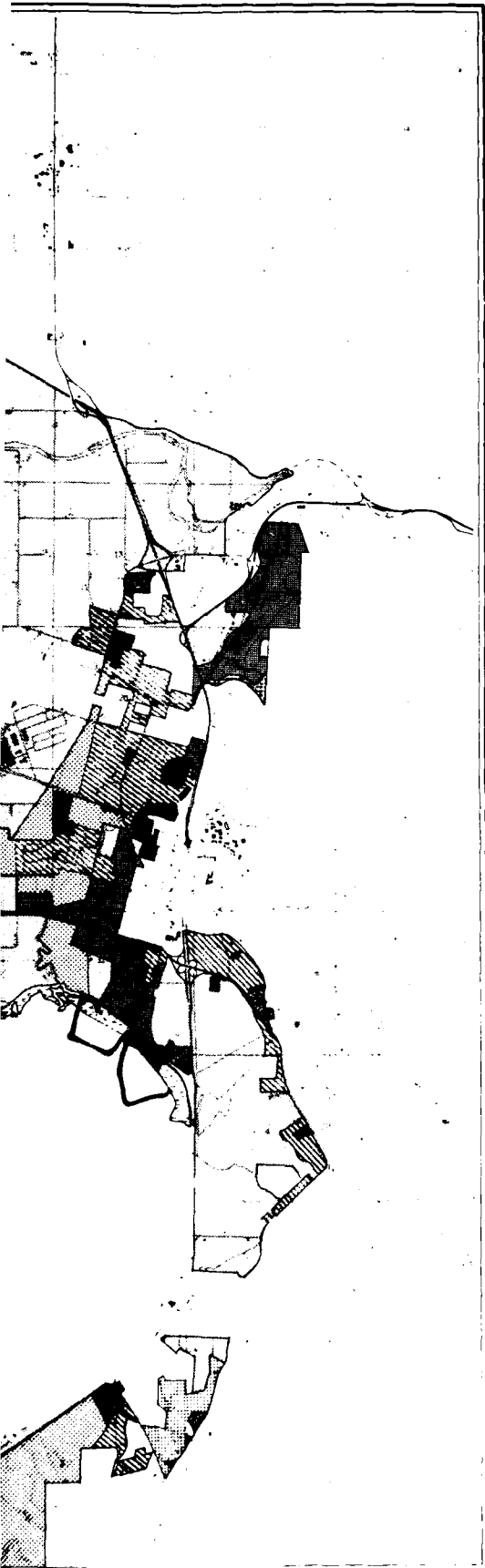
- . Issue Relating to All Coastal Act Policies. Since the impact of the analyses and the resulting policies will have wide-ranging effects on the economic and environmental milieu in which Eureka will exist, it is imperative that any work program address the viability of same and recommend mitigating measures for any negative impacts. The City is not in a position to accept measures which will aide in its own destruction--especially in the long-term.

Zoning

A composite zoning map of the Humboldt Bay study area is shown on Plate 18. The map uses highly simplified and aggregated categories derived from the zoning classifications of Humboldt County, Arcata, and Eureka. Zoning in the heavily urbanized areas of Eureka and Arcata is not mapped. Certain parts of the study area, such as Table Bluff and Elk River Bottoms, are not shown as zoned on Humboldt County maps. The zoning map should not be used as an indicator of allowable uses because of the simplification and aggregation of zoning classes; it is meant to give a general idea of study area zoning for planning purposes. This section describes particular zone types, briefly discusses zoning for each governmental entity, and shows a summary table of corresponding aggregated categories.

FOR PLANNING PURPOSES ONLY
NOT FOR LEGAL USE





ZONING

PLATE NO 18 NORTH

LEGEND

-  Agriculture Exclusive
-  Agriculture
-  Natural Resources Preserve
-  Forest Hill
-  Public
-  Industrial
-  Commercial
-  Residential
-  Unclassified (or not included in source)



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Humboldt County Planning Dept
City of Arcata Planning Dept
City of Eureka Dept of Community
Development

AD-A098 247

SHAPIRO AND ASSOCIATES INC SEATTLE WA
HUMBOLDT BAY WETLANDS REVIEW AND BAYLANDS ANALYSIS. VOLUME II. --ETC(U)
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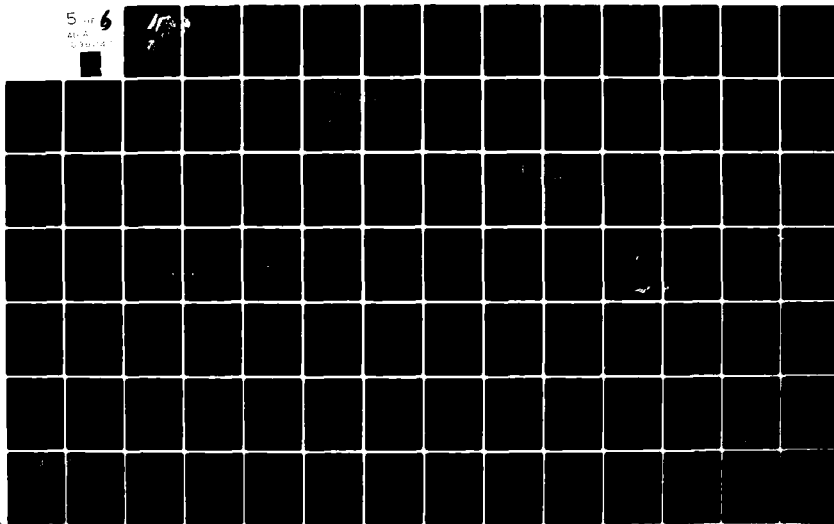
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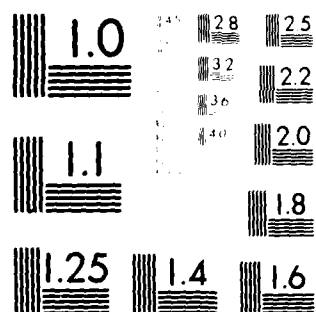
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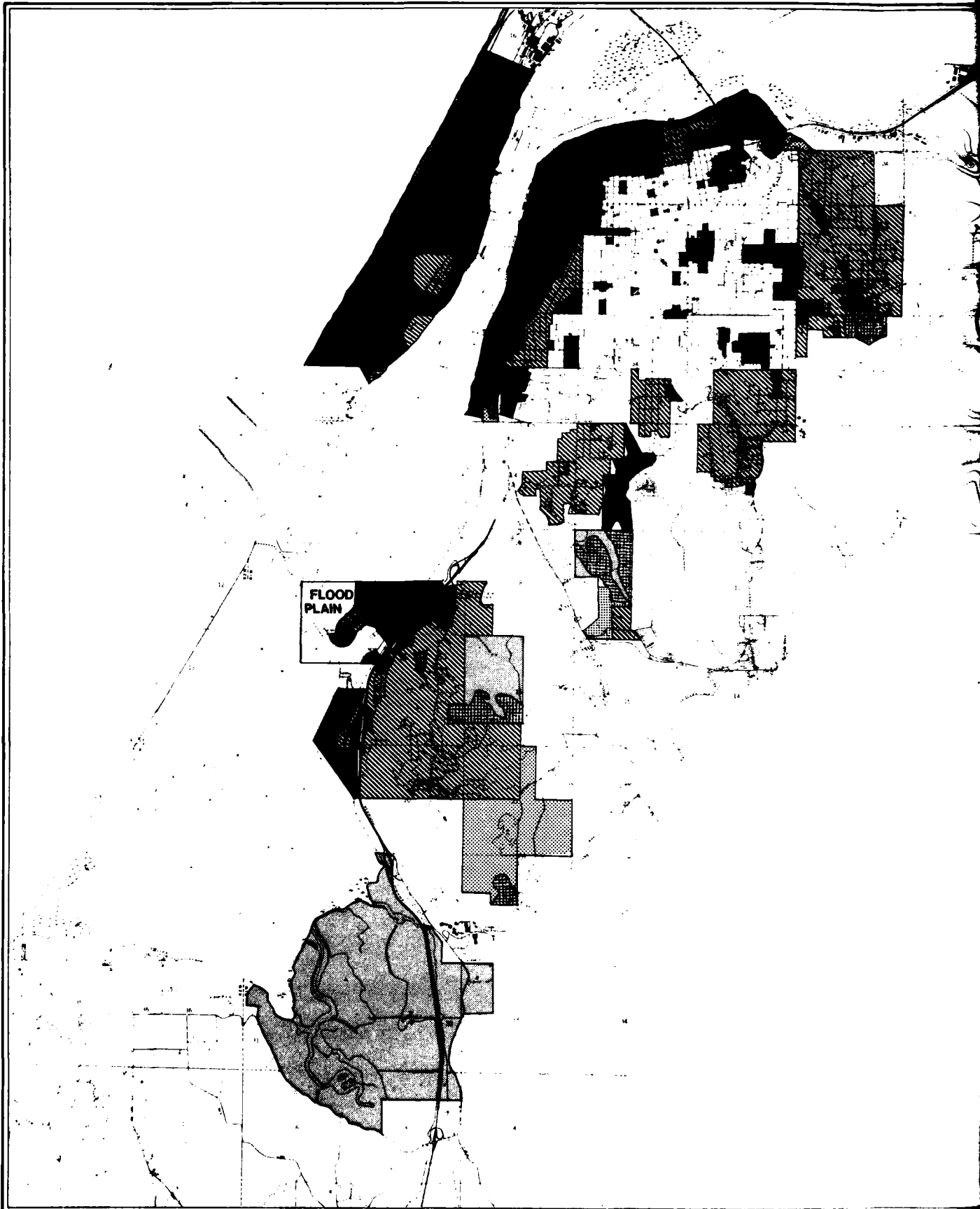
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
MICROCOPY RESOLUTION TEST CHART
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ZONING

PLATE NO 18 SOUTH

LEGEND

-  Agriculture Exclusive
-  Agriculture
-  Natural Resources Preserve
-  Forest Hill
-  Public
-  Industrial
-  Commercial
-  Residential
-  Unclassified (or not included in source)



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Humboldt County Planning Dept
City of Arcata Planning Dept
City of Eureka Dept of Community
Development

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Agriculture-Exclusive (AE) Zone Types. In the course of a study of methods for preservation of agriculture for King County, Washington, Lundin prepared an analysis of California's experience with AE zoning (Lundin, 1976); much of this discussion is from Lundin's work.

Exclusive agricultural zones adopted by California counties permit only agricultural uses and allied uses that are compatible with agriculture, generally exclude non-farm residences, and have large minimum lot size requirements. The use of exclusive agricultural zoning ordinances in California has been widespread. As of 1976, 33 counties had adopted exclusive agricultural zoning ordinances, covering a total of almost 9,650,000 acres. Minimum lot sizes have ranged as high as 100 acres in Alameda County and 60 acres in Marin County. Such minimum lot sizes have generally gone unchallenged. Lundin cites a number of cases in which the courts have upheld exclusive zoning to protect agricultural land; in a recent California case, a county had adopted an exclusive agricultural zoning category, with a minimum 18-acre lot size. The zoning category was upheld, notwithstanding the fact it was applied to land which was in a previously approved subdivision plat permitting 2-1/2 acre parcels, recorded in 1915. The court rejected an inverse condemnation argument and upheld the zoning ordinance (Lundin, 1976).

Analysts of the California experience have concluded that exclusive agricultural zones provide a number of important and defensible policy purposes. Such zones conserve valuable agricultural land from forced premature urban conversion; reduce the demand for municipal facilities and services; and act as a growth management device by containing the spread of development. California courts uphold the validity of the severe restrictions of exclusive agricultural zones, where the land is agriculturally productive, particularly where the zoning classifications are adopted as part of county-wide open space programs, and are carefully defined by land use studies indicating present use, soils, hydrology and productivity.

Timberland Preserve Zone (TPZ). Intended to provide for timberland zoning and restrictions for a minimum 10-year period. The land is valued for tax purposes only on its use for growing and harvesting timber.

Forest Recreation (FR). Intended for forested areas in which timber production and recreation are desirable permitted uses and agriculture is a secondary use. It is meant to protect timber and recreational lands.

Forest/Hillside (FH). Intended for areas suitable for rural or non-intensive urban uses because of steep slopes and/or forest cover. It is intended to prevent excessive removal of vegetation and to ensure adequate grading controls and environmental review. Permitted uses include rural, residential (SF) and public uses.

Natural Resource Preservation (NRP). Intended to preserve natural resources, habitat for fish and wildlife species, areas required for ecological and other scientific study purposes, rivers, streams, bays and estuaries, and the coastal beaches, sand dunes, and banks of rivers and streams. Uses permitted are generally non-intensive uses, such as agriculture, wildlife management, and public facilities.

All three governmental entities have zones for residential (various densities), commercial (various intensities and types), light and heavy industry, and some form of public facilities.

Local Government Zoning

Humboldt County. The AE zone minimum lot size is 20 acres; no subdivisions or residential developments will be permitted. The Agriculture General (AG) zone permits minimum lots of 2.5 acres. The Residential Suburban (RS) zone has a minimum lot size of one acre. The TPZ and FR zones have various allowed uses, but the TPZ is much more restrictive (see Humboldt County LCP above). The Floodplain (FP) and Design Flood (DF) zones are for areas inundated with floods (either past or potential) and areas lying in a designated floodway (Section 8402, California Water Code). Some areas of Humboldt County are Unclassified (U), meaning not sufficiently studied to justify precise zoning and permitting agriculture and some residential development (Humboldt County Zoning Code).

City of Arcata. The AE minimum lot size is 20 acres. The NRP zone is only found in Arcata; it is meant to apply to areas designated Natural Resource/Wildlife Habitat open space by the Arcata General Plan. The FH zone is also an Arcata zone; it is meant for areas designated Forest/Hillside by the Arcata General Plan. Arcata's Residential Agriculture (RA) and Rural Residential (RR) zones have minimum lot areas of 2.5 and 0.5 acres respectively and are viewed as suitable for agriculture and limited agriculture. Arcata has a floodplain combining zone (an overlying zone for flood damage control) (Arcata Zoning Code).

City of Eureka. Eureka does not have an AE zone; the Agriculture (A) zone has a minimum lot size of five acres and the use restrictions are less severe than in an AE zone. Subdivisions are allowed in an A zone. Eureka requires an architectural review in certain areas, in particular along the city waterfront and in the downtown areas (Eureka Zoning Code).

Simplified Zoning Categories

Table VII-11 shows the simplified and aggregated zoning categories used in the zoning map and relates the zoning categories of the various entities to the simplified categories.

LOCAL SPECIAL AGENCIES AND DISTRICTS

Humboldt Bay Harbor, Recreation, and Conservation District (Harbor District)

As described in Section VII-B, Ownership, the Harbor District was established by Chapter 1283, Statutes of 1970, as amended and was actually authorized by the voters in 1973. The granting legislation for the Harbor District specifies its jurisdiction over the following:

- a. All tide, submerged, and other lands granted to the district.
- b. Humboldt Bay, meaning the land and overlying waters, to the limit of tidal action, of what is commonly known as Humboldt Bay, including all rivers, sloughs, estuaries and tributary areas, subject to tidal action as of the effective date of the Act (17 September 1970), including only the portions of Indian, Woodley, and Daby Islands bayward of mean high water.

The Harbor District interprets the phrase "subject to tidal action" as being the elevation of mean higher high water and further specifies its jurisdiction as follows (Harbor District, 1976):

- . Those portions of Indian, Woodley, and Daby Islands bayward of the mean high tide line.
- . Bayward of any functional and authorized tidal gate or tidal control structure.
- . Jolly Giant Creek south of Fourth Street, Arcata.
- . Jacoby Creek west of Old Arcata Road.
- . Fay Slough west of Old Arcata Road.
- . Freshwater Slough west of Old Arcata.
- . Ryan Slough north of Myrtle Avenue.

Table VII-11

AGGREGATED ZONING CATEGORIES

Aggregated Zone	Humboldt County Zones	Eureka Zones	Arcata Zones
Agriculture Exclusive (AE)	Agriculture Exclusive (AE)	---	Agriculture Exclusive (AE)
Agriculture (A)	Agricultural (AG)	Agriculture (A)	Residential Agriculture (RA)
Natural Resource Preservation (NRP)	---	---	Natural Resource Preservation (NRP)
Forest-Hill (FH)	Timber Preserve Zone (TPZ); Forestry Recreation (FR)	---	Forest/Hillside (FH)
Industrial (M)	Industrial (ML, MH)	All Industrial (M)	Industrial (M & M-10)
Commercial (C)	All Commercial (C1, C2, CH)	All Commercial (C)	All Commercial (CN, CU, CB, CT, CH)
Residential (R)	All Residential (RS, RL, R2, R3, R4)	All Residential (RS, RM, OR)	All Residential (RR, RL, RM, RMH, RH)
Public (P)	Airport (AV)	Public (P) and Hospital-Medical (HM)	Public Facility (PF) Medically Related (MRX)
Floodplain (FP)	Floodplain (FP) Design Floodway (DF)	---	Floodplain Combining (:FC)
Unclassified (U)	Unclassified (U)	Unclassified (U)	---

- . First Slough north of Myrtle Avenue.
- . Second Slough north of Myrtle Avenue.
- . Coopers Gulch Slough east of V Street.
- . Swain Slough west of Pine Hill Road.
- . Elk River north of Senestaro Ranch.
- . Salmon Creek west of Highway 101.

The exact line of mean higher high water (MHHW) around the Bay is not known, and thus the exact jurisdiction of the Harbor District is also unclear. Harbor District representatives believe it is absolutely essential to conduct a study (survey) to determine the exact MHHW location. The Harbor District has a five-member Board of Commissioners. The general mandate of the District is to promote development in and around Humboldt Bay and to conserve and protect the Bay resources. Conservation and development are considered of primary importance; promotion of recreation is a secondary purpose (Gast, 1978, personal communication). The Harbor District has permit, planning, and leasing authority over areas under its jurisdiction and may engage in capital construction. Part of the District's mandate is to conserve and protect resources such as wildlife habitat, open space, wildlife and fish, and aesthetics of the area. The District must regulate use and control of pollution, dredging, and filling. As described in Section VII-B, Ownership, the District's tideland grant is a multi-purpose grant. The District may also exercise the power of eminent domain under amendments to Section 30, Ch. 1283, Stats. of 1970 (Ch. 587, Stats. 1975).

In 1974 the Harbor District received an EDA Technical Assistance Grant to prepare a master plan for harbor and port improvement and for the use of tide and submerged lands, (required of the District by Section 19, Chapter 1283, Stats. 1970). The master plan draft was completed in 1975 (Koebig and Koebig, Inc., 1975). In 1976 the Board of Commissioners adopted Ordinance No. 7, implementing certain portions of the 1975 Humboldt Bay master plan. Ordinance No. 7 is the official policy of the Harbor District; important points in this ordinance are summarized below.

1. Ordinance No. 7 describes land and water use designations and use limitations which should generally apply. These are:

- a. Conservation Water. Use limited to natural resources habitat, wildlife refuges, mariculture, public access, and scenic vistas.
 - b. Development Water. Use limited to access for commercial and industrial users and to improved and maintained channels.
 - c. Public Open Space Land. Use limited to natural resources habitat, wildlife refuges, recreation, public access, and scenic vistas.
 - d. Agriculture Land. Use limited to crop and livestock production.
 - e. Service/Commercial Land. Use limited to commercial activities that are dependent on proximity to the waterfront; might include enterprises such as restaurants and specialty shops.
 - f. Port Related Industrial Land. Use limited to waterfront developments requiring direct access to deep-water shipping channels.
 - g. Water Related Industrial Land. Use limited to waterfront developments requiring direct access for shallow draft vessels or requiring industrial cooling water.
 - h. Nonwater Related Industrial Land. Use limited to waterfront developments dependent upon but not requiring direct access to the waterfront.
2. Ordinance No. 7 designates the waters and adjacent uplands into the various use categories as summarized below:
- a. Conservation Waters. Generally include all waters of North and South Bay, the area around Indian Island shoreward of the Samoa and Arcata channels, and the area east of the improved and maintained channels from King Salmon north to and including Elk River.
 - b. Development Waters. Generally include the Middle Bay waters from the Bay entrance along the Hookton Channel to south of Fields Landing and north along the channels to the Eureka-Samoa Bridge (not including the Conservation Waters above).
 - c. Public Open Space/Agricultural Lands (jointly designated). Generally include all uplands adjacent to South Bay in the South Spit, Table Bluff, and Beatrice Flats areas, all uplands adjacent to North Bay in the Arcata

Bottoms, Bayside Bottoms, and Eureka Slough areas except the area from the Eureka Slough Highway 101 Bridge along the north side of Eureka Slough to and including Murray Field, and the North Spit from Mad River Slough south to the Eureka-Samoa Bridge.

- d. Public Open Space Lands. Generally include Indian Island, the northwesterly two-thirds of Woodley Island adjacent to the Arcata Channel, the South Jetty and the North Spit from the Entrance Channel and the North Jetty north to the northern boundary of Section 32 of T5N and R1W, Humboldt Meridian (located north of the Samoa Boat Ramp), the area northwest of Buhne Drive, King Salmon, and the Elk River Spit from the Highway 101 Bridge south and west to the northern boundary of the southwestern quarter of the southwestern quarter of the southwestern quarter of Section 4 of T4N and R1W, Humboldt Meridian (located near Spruce Point).
- e. Agricultural Lands. Covers an area from the northern boundary of the southeastern quarter of the southeastern quarter of Section 5, (located near Spruce Point) southwest (toward King Salmon) to the northern boundary of the southeastern quarter of Section 8, all in T4N, R1W, Humboldt Meridian (this is a quite small area).
- f. Service/Commercial Lands. Generally include King Salmon south and east of Buhne Drive to near the north end of Fields Landing.
- g. Nonwater Related Industrial Lands. Include the area from the Eureka Slough Highway 101 bridge to and including Murray Field and an area from just below the tip of Elk River Spit south of Bucksport to the Elk River Highway 101 bridge.
- h. Water and Port-Related Industrial Lands. Generally include the Eureka-Bucksport area from the Eureka Slough Highway 101 bridge to south of Bucksport, an area from Spruce Point to the north end of Buhne Drive, King Salmon, and North Spit from north of the Samoa Boat Ramp (boundary of Section 32) to the Eureka-Samoa bridge.

The Harbor District recognizes that its jurisdiction does not include adjacent uplands and that implementation of upland designations will require cooperative efforts with other local jurisdictions. The District will promote development in and around the Bay consistent with the

designations and master plan. In particular, areas designated public open space and agriculture will be maintained and protected.

3. Ordinance No. 7 specifies operational policies for general property acquisition and use, navigation, industrial development, public access, tourism/recreation, aquaculture, research/education, dredging, diking, filling, and maintenance of environmental quality.

In the Humboldt Bay study area, the Harbor District is sponsoring several projects, including the Woodley Island Marina and a boat repair and construction facility. The District is concluding plans to acquire an old logging pond just west of Freshwater Slough north of Park Street (Glatzel, 1979, personal communication). Under its permitting authority the Harbor District recently approved a permit for a trans-bay crossing for the regional sewer system (see HBWA below).

North Humboldt Park and Recreation District

The District was formed principally to be a taxing body to collect funds for a recreational swimming pool in Arcata. The boundaries were set to encompass enough area to assure sufficient use and revenues. The District has some difficulties with the pool management and expects to turn the pool over to the City of Arcata (Glatzel, 1979, personal communication). It has no other recreational facilities.

Humboldt Bay Wastewater Authority (HBWA)

The Humboldt Bay Wastewater Authority (HBWA) is a joint powers agency whose original purpose was to design, construct, and operate a regional wastewater system to serve its members. The membership includes the cities of Eureka and Arcata, Humboldt and McKinleyville Community Service Districts (HCSD and MCSD), Humboldt County Service Area (CSA #3), and College of the Redwoods. The principle impetus for the regional system came from the adoption of Bays and Estuaries policy (see State Water Resources Control Board above). This policy severely limited the choices available to Humboldt Bay communities for wastewater treatment, by banning discharge of sewage into Humboldt Bay unless such discharge could be proved to enhance Bay waters.

A Joint Exercise of Powers Agreement (JPA) was executed between Eureka, Arcata, HCSD, MCSD, and Humboldt County (for CSA #3) in 1975; this JPA superseded the 1974 agreement between Eureka and HCSD creating the HBWA. The 1975 JPA was amended three times, once

for administrative matters and twice for changes in system design/capacity (Stratford, 1979, personal communication). An amendment (29 November 1978) reflected a major design change, the elimination of an East Bay Interceptor from Arcata to Eureka and the substitution of a North Bay Interceptor, connecting Arcata to the McKinleyville Interceptor.

The 1978 JPA reserved capacity allocations for each of the participants in the HBWA. The system design capacity was based on population projections for 1985 and 1995 for the area. Capacity allocations to the various participants were based on population projections in their service areas. The capacity allocation for Arcata included the Arcata planning area and the Jacoby Creek CWD (Bayside area) (Stratford, 1979, personal communication).

Since the initiation of the regional sewer project, it has had considerable local opposition. Concern about growth was a principal reason for revision of the system to eliminate the East Bay Interceptor. There was also local opposition to the trans-Bay crossing near Eureka (part of the proposed system) because of the possibility of a break in the line with the resulting release of untreated sewage into the Bay. Further, the City of Arcata has been very interested in innovative approaches to wastewater treatment, including water reclamation and ocean ranching (see Local Governments, City of Arcata, Department of Public Works above). The applicability of the Bays and Estuaries policy to Humboldt Bay was questioned by local agencies and residents. The State Water Resources Control Board (SWRCB) has promulgated interpretations of the enhancement provision of the Bays and Estuaries policy specific to Humboldt Bay (see SWRCB above). As a result of SWRCB public hearings in April, the Board concluded that local opposition to the regional system had intensified to such a point that timely and cost-effective implementation of the project appeared unlikely. The agencies in HBWA are presently planning (either independently or in subgroups) for sewage management and treatment facilities which will be acceptable to SWRCB without the necessity for an ocean discharge (Stratford, 1979, personal communication). However, the enhancement criteria of the SWRCB must be met for any discharges into Humboldt Bay by any of these agencies. The SWRCB required that a contingency plan for ocean discharge of sewage be developed in the event that enhancement could not be proven for Bay discharges.

The agencies composing HBWA are now involved in developing sewage collection and treatment facilities plans. The status and thrust of each agency's planning is summarized below; all information is from a representative of HBWA (Stratford, 1979, personal communication):

1. McKinleyville Community Service District (MCSD) is developing a Step 1 Facilities Plan (Step 1 of EPA's granting

process). The MCSD is considering a facility which will discharge into the Mad River upstream of the estuarine waters, so that the discharge will be out of the range of the Bays and Estuaries Policy. The MCSD has received some support from the State for this idea, because of the small size of the discharges. Early planning indicates that direct discharges would be allowed during high flow months on the Mad River, while low flow months would require some form of indirect discharge. Land application or settling beds (gravel bottoms) are possibilities for indirect discharge. The Step 1 planning effort will continue into the design phase in summer or fall of 1980 and then into construction.

2. The City of Arcata is using several different approaches to sewage management. The City's wastewater reclamation project (Arcata Department of Public Works above) is proceeding on a pilot project. The City is upgrading its existing treatment plant and is also doing some Step 1 planning to review existing plant unit processes for possible upgrading.
3. The other three principal HBWA agencies (Eureka, HCSD and CSA #3) are continuing together, either through the existing HBWA structure or through a new structure with Eureka as the lead agency. In the latter case, the HCSD, MCSD, and College of the Redwoods could contract with Eureka for service. The interceptors in the City of Eureka will be completed with consolidation of wastewater flows to the Murray Street treatment plant; this involved 4-5 miles of interceptors and 3 new pump stations. This is an interim sewage management measure which would fit either the regional system or other future plans for the City. These system improvements must be under construction by April 1980 to comply with conditions on the loan extension granted by the State. For the future, a new treatment plant serving Eureka, HCSD, and MCSD could be located either at the existing Murray Street site or near the Elk River. Factors influencing the location of a secondary treatment plant with discharges to the Bay include the marsh development potential and the need for holding facilities with discharges on the outgoing tide near the Bay mouth.

As mentioned above, Eureka, Arcata, MCSD, HCSD, and CSA #3 (and College of the Redwoods) are all still members of HBWA. The present intent is to keep HBWA active for the following activities:

- . Management of the State's loan extension and audit of grant funds.

- . Regional coordination of the subregional public participation program required for each agency or group engaged in facility planning.
- . Development of a contingency plan for ocean discharge. The contingency plan could involve sewage treatment at the various individual locations with an ocean outfall of treated effluent. This would mean that any trans-Bay or North Spit lines would not carry raw sewage.

In addition, HBWA already has authorization for issue of revenue bonds, which could possibly be used as a method of funding construction of any individual facilities. However, HBWA would then own the facilities.

Redwood Region Economic Development Commission (RREDC)

The RREDC is an organization formed to coordinate efforts for economic development in Humboldt County. At the time of contracting for the Economic Development Action Plan (QRC, 1978), the RREDC was not a legal entity. The QRC contract was with Humboldt County until the RREDC became viable 1 November 1977. The RREDC then reviewed and accepted the Action Plan and used it as a base for obtaining EDA Title 9 funds (Ridenhour, 1978, personal communication).

The RREDC membership includes the following entities:

Humboldt County
 Cities of Eureka, Arcata, Fortuna, Blue Lake, Rio Dell,
 Trinidad, and Ferndale
 Humboldt Bay Harbor, Recreation, and Conservation District
 Humboldt Bay Municipal Water District
 Redwood Community College District
 Humboldt Community Services District
 McKinleyville Community Services District
 Willow Creek Community Services District

A joint powers agreement between these entities has been executed. Separate commissions, such as the Arcata Economic Development Commission, are associated with each of the member entities.

The RREDC intends to continue to coordinate grant seeking and funding of economic development projects. The Commission accepts and reviews loan applications and allocates its granted monies to various projects. The RREDC received a \$5.5 million grant for one year in September 1978. The agency will apply for a new grant for 1979-1980; it will probably include one public works project and some administrative funds, but the majority of the grant will be for economic assistance and development loans to businesses. A summary of RREDC grants and loan applications is in Section VIII-C, Economics.

Humboldt County Local Agency Formation Commission (LAFCO)

The Local Agency Formation Commission is a regulatory body responsible for the discouragement of urban sprawl and for the orderly formation of local governmental agencies. LAFCO is required to review and approve or disapprove city incorporation, disincorporation, and consolidation, formation or reorganization of special districts, and annexations of territory to local agencies, provided that LAFCO may not impose any conditions which would regulate land use or subdivision. Factors considered by LAFCO in review of proposals include:

- . Population and density, land use, natural boundaries, probability of significant growth in the area.
- . Need, cost, and adequacy of public services and effects of the proposal (cost/revenue and demand/capacity).
- . Effects on adjacent areas, social and economic interests and governmental services.
- . Conformity with LAFCO and statutory policies.
- . Effects on agricultural preserves and open space uses.
- . Relationship of boundaries to ownership or assessment lines and the creation of islands.
- . Conformity with city or County general or specific plans; spheres of influence (a plan for the probable ultimate physical boundaries and service area of a local governmental agency, as determined by LAFCO. Spheres of influence for most agencies were adopted coterminous with their existing boundaries, except for Arcata, whose sphere of influence was larger (DeCamp, 1979, personal communication).

In 1978 LAFCO reviewed and acted on 16 applications, 15 for annexations and one for restoration of latent powers to a special district outside the Humboldt Bay study area. Of the annexation proposals, 8 were located in the study area; six for Arcata, one for Humboldt Community Services District (CSD), and one for Jacoby Creek County Water District (CWD). The Humboldt CSD and Jacoby Creek CWD annexations were approved for 37.8 and 80 acres respectively. Five of the six Arcata applications were approved for a total of about 347 acres; a 4.56 acre annexation to Arcata was denied. (LAFCO, 1978)

Humboldt County Air Pollution Control District (HCAPCD)

The District has operated for the past 10 years with partial federal funding provided by the EPA. It has primary responsibility for regulating stationary source emissions. The Districts have the authority to adopt rules limiting emissions of various pollutants, issue construction and operating permits for stationary sources, and to take enforcement action against violations of state or district rules. The District was originally formed separate from the County Health Department because of the specialized technical nature of air pollution problems caused by the two kraft pulp mills in the Eureka area (odorous sulfur compound emissions). The HCAPCD handles all air pollution control activities in Humboldt, Trinity, and Del Norte Counties and makes services available to Sonoma and Mendocino Counties. (NCAPCC, 1977)

Other Special Purpose Districts

Community Services Districts (CSD). There are three Community Services Districts in the Humboldt Bay study area: the Humboldt CSD, the Manila CSD, and the McKinleyville CSD, all shown on Plate 19. The Humboldt CSD provides water and sewer service and street lighting (LAFCO, 1979); this district contracts for water from the Humboldt Bay Municipal Water District (HBMWD, see below) and with the City of Eureka for wastewater treatment (QRC, 1978). HCSO provides water to College of the Redwoods, Fields Landing Water Company and Reynolds Water Company service areas (QRC, 1978).

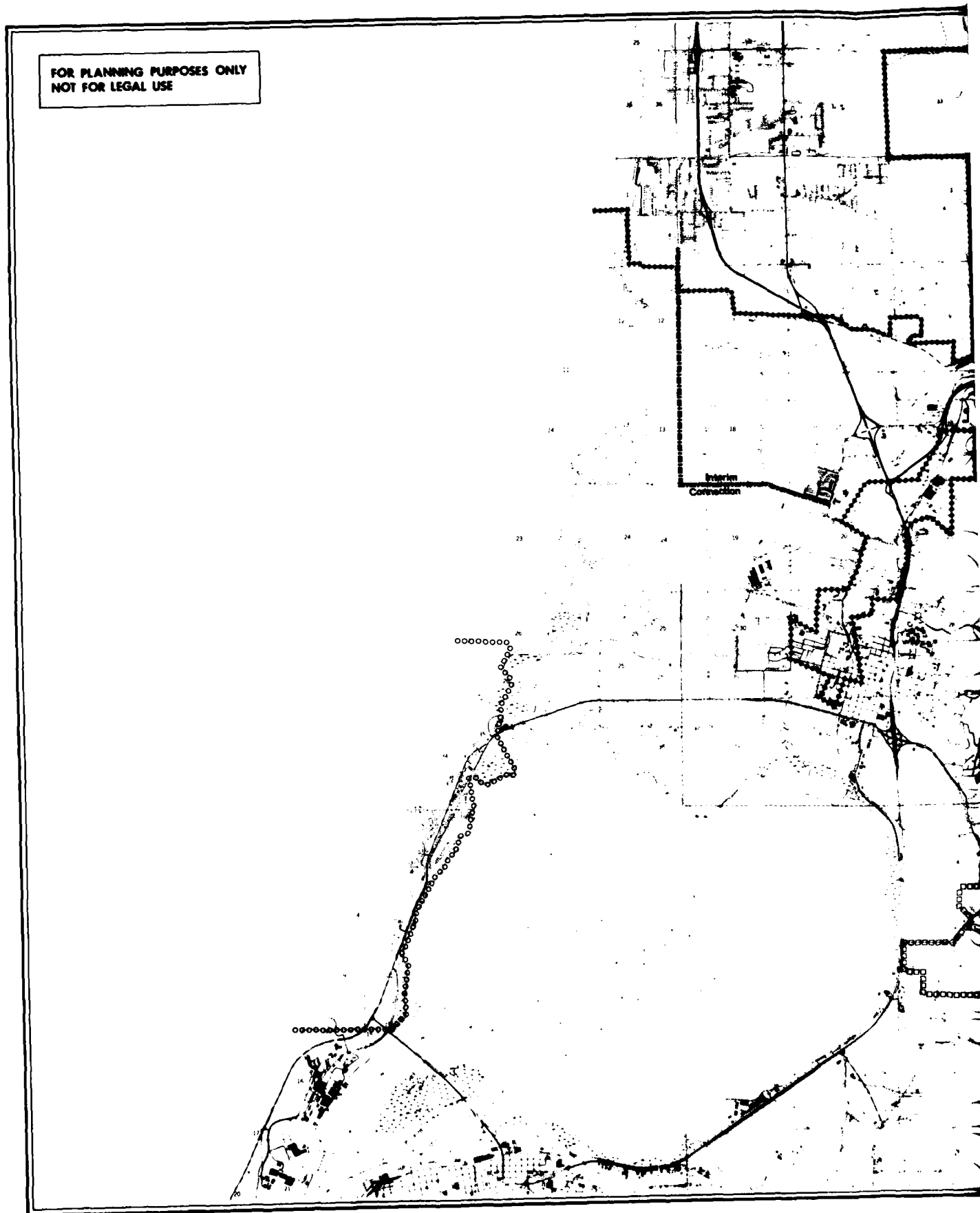
The Manila CSD provides water and street lighting and has sewer powers, but no sewer service as of February 1979 (DeCamp, 1979, personal communication). The district contracts with HBMWD for water. A collection system design for the community has been authorized, but not built.

The McKinleyville CSD provides water and sewer service and street lighting. The MCSO contracts with HBMWD for water and has built a sewage collection system.

All three districts will connect to the HBWA interceptor system.

Water and Sewer Districts. There are two water districts in the study area (Plate 19): the Humboldt Bay Municipal Water District (HBMWD) and the Jacoby Creek County Water District (JCCWD). The HBMWD is the principal supplier of water in the Humboldt Bay region, with lines serving Arcata, Eureka, the entire North Spit, and Humboldt CSD (QRC, 1978). As a wholesaler HBMWD contracts to supply its customers with specified amounts of water. The Jacoby

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SPECIAL DISTRICTS

PLATE NO 19 NORTH

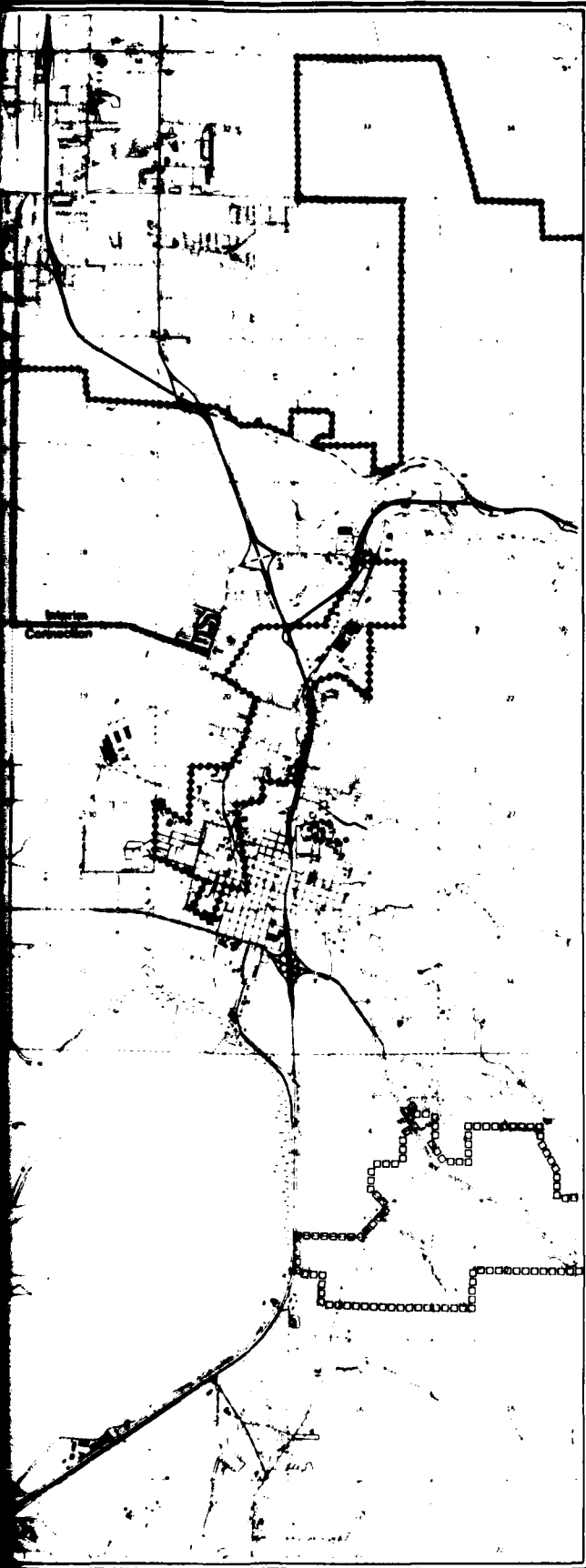
LEGEND

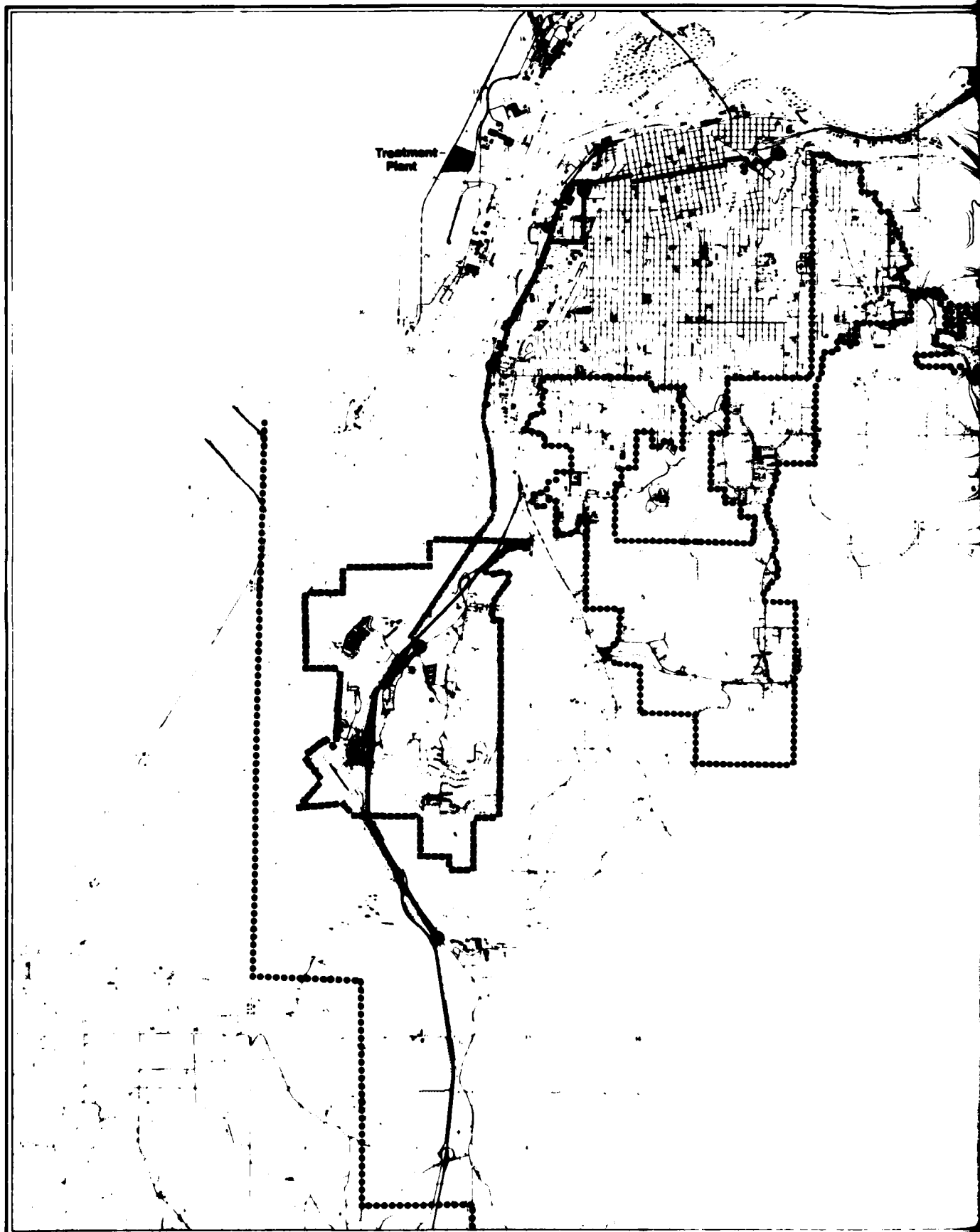
- McKinleyville CSD
- Jones Creek SMD
- Manila CSD
- Jacoby Creek CWD
- HWBA Sewer Line
- Harbor District (see text)



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Humboldt County Local Aging Formation
Commission





SPECIAL DISTRICTS

PLATE NO 19 SOUTH

LEGEND

- Humboldt Bay MWD
- County Service Area
- Humboldt Bay CSD
- HWBA Sewer Line
- Pumping Station
- Harbor District (see text)



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Humboldt County Local Aging Formation
Commission

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Creek CWD is authorized to supply water to customers within its service boundaries; it has no drainage or flooding plans (DeCamp, 1979, personal communication).

Country Service Area #3 (CSA #3, Plate 19) provides sewer service for King Salmon, Fields Landing, and Sea View Manor with a separate collection and treatment system for each. All three use treatment lagoons which then discharge to the Bay.

Fire Districts. There are four fire districts in the study area, shown on Plate 19; they are Arcata, Fairhaven, Humboldt #1, and Loleta in the far south portion of the study area.

Miscellaneous Districts. The Janes Creek Storm Drainage District was organized to provide drainage and flood control services. This district is not under LAFCO jurisdiction (DeCamp, 1979, personal communication). The Pacific Manor Lighting District, a tiny district near Janes School, provides street lighting.

Section VIII

CULTURAL AND ECONOMIC PROFILES

VIII. CULTURAL AND ECONOMIC PROFILES

This section presents data in three profiles: Cultural, Aesthetic, and Economic. The purpose of these profiles is to provide a picture of the cultural resources and economic situation of the Humboldt Bay area. Such a picture is essential to an understanding of the value of the area and of the potential pressure to change and develop the Bay area lands and waters.

A. CULTURAL RESOURCES PROFILE

This profile is a description of cultural resources in the study area. Information is presented in sections as follows:

1. History of Settlement and Development
2. Community Structure
3. Recreation Resources
4. Educational and Scientific Use
5. Refuges and Reserves

1. History of Settlement and Development

The history of the settlement of the Humboldt Bay area is presented in two parts: the Native American Wiyot settlement, with mapping of archeologically sensitive areas; and the European discovery, settlement, and development, with mapping and description of historical sites and resources.

The Native American Wiyot

The Native American Wiyot tribe, part of the Algonkian family, occupied approximately 465 square miles of territory. The Wiyot territory was divided into three natural divisions: the lower Mad River, the Humboldt Bay area, and the lower Eel River. The Humboldt Bay study area encompasses approximately one-third of the lower Mad River and the entire Humboldt Bay area division.

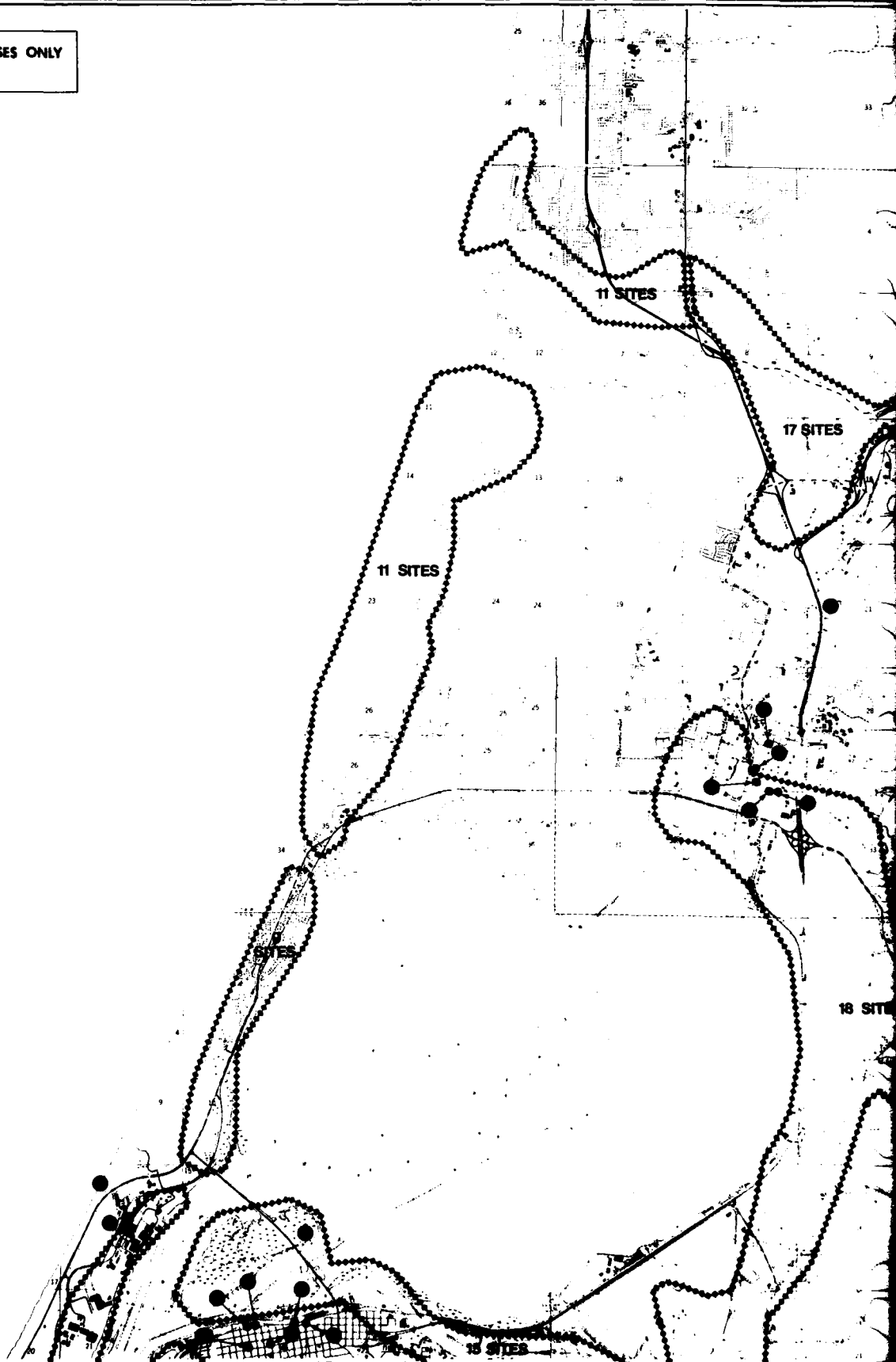
The Wiyots occupied 172 prehistoric and historic village sites which are estimated to have been settled between 25 B.C. and 1050 A.D. Wiyot settlements were located in close proximity to rivers, streams, the bay, and the sloughs. A primary method of travel was by fire-hollowed, redwood log canoes. The Wiyots depended heavily on the resources of Humboldt Bay and surrounding marsh and grasslands and consequently had developed a complex fishing technology. Detailed descriptions of the Wiyots and the use of their resources are given by Benson (1976), Loud (1918), Nomland (1936), Kroeber (1960), and Kellog (1973).

The Wiyot population was estimated to be 1,000 persons in 1850, 800 persons in 1853, and 152 full or part-blooded persons in 1910. Specific census data for individual tribal affiliations are not taken, making it impossible to estimate current status of the Wiyot. The abrupt reduction in the Wiyot population was caused by a combination of factors, including the introduction of new diseases and displacement of food resources and living area by white settler land claims. Hostilities with the settlers resulted in murder, massacre, and mistreatment of the Wiyot, including starvation and exposure after removal to reservations.

Plate 20 shows archeologically sensitive areas in proximity to Humboldt Bay. The grave sites of the Wiyot are located close to village sites; therefore, specific site locations are confidential and not pinpointed. Humboldt County Department of Public Works records estimate a total of 117 known sites in the project area. Most of the recorded sites are village and burial sites. Other sites in the study area important to the Native American culture are sacred and ceremonial sites. Examples of sacred and ceremonial sites include trails, fishing, clamming, and ceremonial grass gathering sites. The estimate of known sites in the project area is based on archeological survey records from various sources. Many other sites are assumed to exist, but have not been located or described. Loud (1918) described 115 sites, a majority of which are in close proximity to Humboldt Bay. In 1936, Nomland described 36 sites in the area and 10 sites were relocated by Benson (1976). Members of the Northwest Indian Cemetery Protection Association (NICPA) have located additional sites. Sonoma State University Anthropological Study Center Cultural Resources Facility is the Northwest Regional Center for the California Archeological Survey which maintains survey records for all known sites in nine California counties, one of which is Humboldt. A bibliography of survey records in the Humboldt Bay area was prepared and reproduced by Benson (1976).

Humboldt County Resolution No. 71-14 establishes the Humboldt County policy regarding archeological features as Indian graves, burial grounds, cemeteries, and ceremonial sites within the county. The county is given authorization to consult with NICPA and other interested Indians on archeological features. NICPA acts as a clearinghouse for information regarding sacred and ceremonial sites. The NICPA archeologist cooperates with the Sonoma State University Anthropological Study Center which is the district clearinghouse for the Society for California Archeology on village and burial sites. A fee per hour is charged by the NICPA archeologist for review of proposed development plans to ascertain the existence of archeological and sacred sites in proximity to the project. If no sites are known to be located in proximity, approval for the project is given with a clause that all construction is to stop immediately if a site is found. If a site is known to be located in proximity to a proposed development, a NICPA archeologist and often a Native American observer

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ARCHAEOLOGY / HISTORY

PLATE NO 20 NORTH

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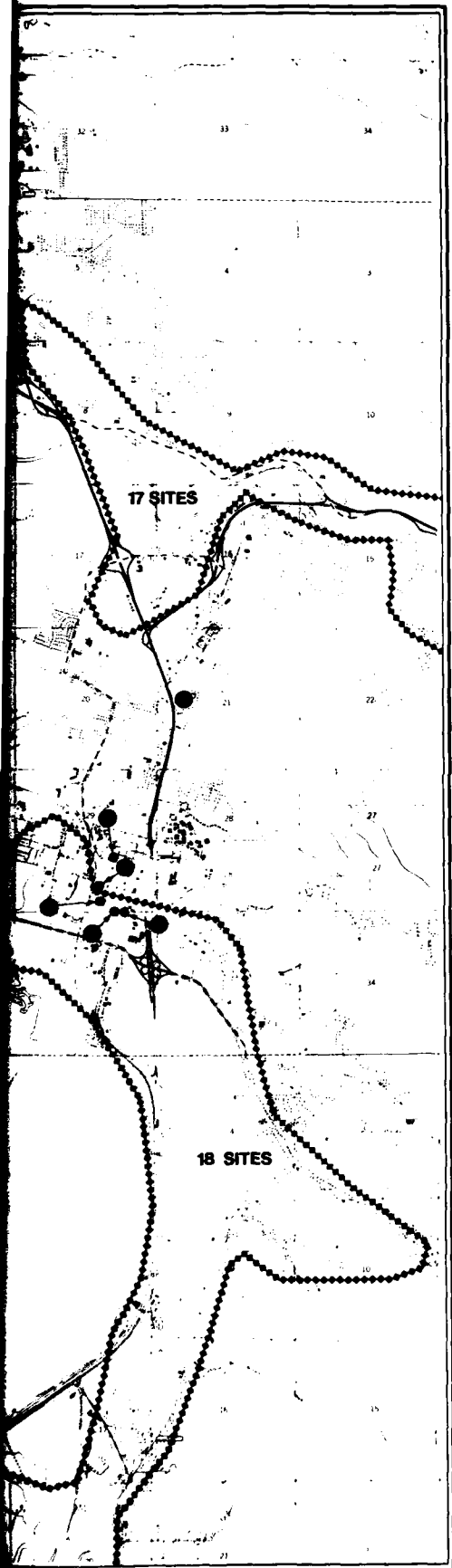
• Historical Sites

..... Arch. Sensitive Areas



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Humboldt County Dept of Public Works
Natural Resources Division
California State Historic Preservation Office





ARCHAEOLOGY / HISTORY

PLATE NO 20 SOUTH

LEGEND

• Historical Sites

Arch. Sensitive Areas



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Humboldt County Dept of Public Works
Natural Resources Division
California State Historic Preservation Office

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must be retained on the site during trenching or bulldozing phases of the construction. If there will be significant disturbance to a site during construction, the adverse impact to the site must be mitigated. Archeological testing of the site must be performed prior to construction to ensure site integrity.

One prehistoric Indian site in the Eureka vicinity (Gunther Island Site 67, Tolowot), is on the National Register of Historic Places.

The European Discovery, Settlement, and Development

The first recorded discovery of Humboldt Bay by European civilization occurred in May 1806 by Captain Jonathan Winship of the vessel "O'Cain" while in temporary fur service trade to the Russian America Company. The party named the bay the "Bay of Resanof" but also called it the Bay of Indians.

Forty years later, interest developed in locating a port of trade to the gold mines in the Trinity and Siskiyou mountains. The land party of Dr. Joseph Gregg reached the bay on 20 December 1849, naming it "Trinity Bay." No land claims were made as the party intended to return the following spring from San Francisco.

The first claim to Humboldt Bay by Anglo Americans occurred on 14 April 1850 by the "Laura Virginia" party. Humboldt City was established at Red Bluff near Buhne Point and the bay was named after the German naturalist, Baron Alexander von Humboldt. The Union Company overland party claimed land to form Bucksport and Union (Arcata) on 19 April 1850. The Mendocino Company, by agreement with the Union Company, claimed Eureka on 13 May 1850.

During 1850 and 1851 the Humboldt Bay area quickly became a trade depot. Trails were constructed inland to the gold mines and a packing business grew rapidly. In the following years the lumber industry provided the main impulse to growth in the area. Early lumber manufacturing was confined to pine, spruce, and fir. In 1852 the first redwood lumber mill of Ryan, Duff & Company was located on Humboldt Bay and by 1854 nine mills employed about 300 men. In 1855 the first cargo of redwood was shipped to Hong Kong by the Carson Mill. From 1855 to 1914, 8.3 billion board feet of lumber was harvested. By 1952, average production reached over one billion board feet cut per year.

Between 1850 and 1870 agricultural activity was restricted to cattle and sheep grazing in the prairie areas near Arcata, Eureka, and Humboldt Hill. By 1871 the Arcata bottoms were completely cleared of the thick stand of willows, alder, and spruce. Between 1870 and 1880, clover planting became successful, making dairy farming possible. In the 1890's extensive diking of the Humboldt Bay

salt marsh areas resulted in a greater quantity of available pasture-land. By 1912 efforts at soil improvements resulted in a greatly increased vegetable crop harvest.

Fishing and ship building efforts were located on the North Spit and centered in the communities of Rolph (Fairhaven) and Finntown. By 1875 about 25 ships and boats had been constructed. Much of the appropriate fishing technology was either adopted from the Wiyots or introduced, as in the case of salmon trolling introduced by Finnish immigrants.

By 1860 the total Humboldt County population was 2,694 with approximately 1,600 persons living in close proximity to Humboldt Bay. In 1870 there were about 3,700 settlers and by 1880 the population had reached about 10,000 in the Humboldt Bay area out of a county total of 15,512. From 1880 to 1960, the county population continued to grow, but between 1960 and 1970, the population decreased by 5%. It has been estimated that between 1960 and 1970, almost one-third of the 1960 residents left the county and were only partly replaced by in-migration.

The California Inventory of Historic Resources (1976) lists 22 sites or areas in the study area. These sites are shown on Plate 20 and are listed below:

1. Arcata Plaza, Arcata
2. Bucksport, Eureka
3. Camp Curtis, Arcata
4. Carson House, Eureka
5. Carson Mansion (Ingomar Club), Eureka
6. Eureka, City of
7. Eureka Chinatown, 4th and E Streets
8. First and F Street Building, Eureka
9. Fort Humboldt (State Historic Park), Eureka
10. Gunther Island Site 67, Humboldt Bay
11. Hanna House, Eureka
12. Harte (Bret) House, 9th and J Streets, Arcata
13. House at 14th and J Streets, Arcata
14. House at 314 H Street, Eureka
15. Humboldt, City of
16. Humboldt Cultural Center (E. Janssen Building), Eureka
17. Humboldt Harbor Historical District, Eureka (Spruce Point)
18. Jacoby Building, 8th and H Streets, Arcata
19. Nixon House, 1022 - 10th Street, Arcata
20. Rolph (Fairhaven)
21. Sequoia Park, Eureka
22. Northsville, Samoa

The State of California Points of Historical Interests (in press) notes two additional sites:

23. Zane Road Bridge, Elk River
24. U.S.S. Milwaukee, Samoa (Pacific Ocean)

Two of the sites listed above are on the National Register of Historic Places:

8. The First and F Street Building
16. The Humboldt Cultural Center (E. Janssen Building)

The following five sites or areas are Registered California Landmarks:

3. Camp Curtis, near Arcata (#215)
6. City of Eureka (#477)
9. Fort Humboldt State Historic Park, Eureka (#154)
17. Humboldt Harbor Historical District, Spruce Point (#882)
18. Jacoby Building, Arcata (#783)

The California Inventory of Historic Resources and the California Points of Historical Interest are not official registers; they are inventories of outstanding historical features.

Various entities have conducted historical surveys in the study area. The City of Arcata historical survey of 1979 lists 149 structures. Two structures on the list have been adopted by the City as having significant historical value: the Schorlig house at 1050 12th Street, and the Jacoby Building (#18 above). Arcata has classified seven houses in the coastal zone as Potential National Register Sites and three other houses as Other Sites (of historic significance to the community). All but one of these are located between 7th Street, Samoa Boulevard, F Street, and K Street. The Eureka Heritage Society has conducted an architectural and historical survey in the city of Eureka between 1973 and 1979. Of the approximate 10,000 structures inventoried, 1,500 have been selected as significant for historical background or historical based on National Register Criteria. The society can be contacted on a need-to-know basis as the inventory is not yet published. The County of Humboldt completed a Historic Resources Survey Report in 1979 along Old Arcata Road which identified 135 sites. The State Historic Preservation Officer has recommended 32 of the 135 sites to be eligible for the National Register.

2. Community Structure

This section describes the population, income level, and community demographics in the study area. Adjacent communities dependent on the study area for services are briefly described. The Humboldt Bay area is a center of services and trade for all Humboldt County communities and a major metropolitan center of northwestern California. Communities tend to decrease in population and become more rural with greater distance from Humboldt Bay.

Population

According to the U.S. Census Bureau, Humboldt County had a total population of 99,692 in 1970. The county urban population was estimated to be 47,045, of which 71% resided in the city of Arcata (population 8,985) and the city of Eureka (population 24,337).

The mid-Humboldt County planning area includes the incorporated cities of Blue Lake, Trinidad, Arcata, and Eureka, the entire Humboldt Bay area and the many small communities in the drainage basins of Salmon Creek, Elk River, and other small creeks to the north. This planning area was estimated to have a 1970 population of 72,000 to 73,500 (Baruth and Yoder, 1971(1)), representing about 73% of the total 1970 county population.

By 1977 the Humboldt County population had increased to an estimated 106,000 (California Department of Finance, 1978) which extrapolates to about 78,000 for the mid-Humboldt County planning area. Baruth and Yoder (1971) projected a population increase for the mid-county area to about 135,000 by the year 1985; these projections emphasized amount of available land and are considered to be much too high by the Humboldt County LCP planners (Dunn, 1979, personal communication). Population distribution patterns are not projected to change dramatically from the present pattern of approximately 70% of the county population residing in the mid-Humboldt County area.

The Metcalf and Eddy report (1974) for the proposed Regional Wastewater Management Plan used a study area smaller than the mid-Humboldt County planning area; it was limited to Eureka, Arcata, the entire Humboldt Bay, and the drainage basins of Salmon Creek, Elk River, and Ryan, Freshwater, and Jacoby Creeks. Humboldt Community Services District and County Service Area No. 3 (both sewer service districts) are included in the Metcalf and Eddy study area. In 1970 the area had a population of about 57,500, which was forecasted to increase to about 83,100 by 1995 (Metcalf and Eddy, 1974). This is a slightly greater rate of increase than was forecasted for the mid-Humboldt County planning area. The forecasted growth was distributed in Arcata (an increase of 85% over 1970, Humboldt Community Service District (increase of 65%), and County Service Area No. 3 (increase of 63%), Eureka (increase of 20%), and the county areas within the study area (overall increase of 39%).

Income

Humboldt County adjusted gross income levels for 1976 returns (Table VIII-1) indicates a low to moderate income base. In 1970 (U.S. Census, 1973), a breakdown of income by community showed a median income of \$9,154 for Humboldt County, \$9,108 for Eureka, \$10,141 for Arcata, \$10,394 for rural farm, and \$8,974 for rural non-farm. No specific income information exists for individual communities in the study area.

Table VIII-1

ADJUSTED GROSS INCOME LEVELS FOR HUMBOLDT COUNTY
1976 Income Year

<u>Adjusted Gross Income Levels</u>	<u>Number of Returns</u>
0 - 5,000	10,853
5,000 - 10,000	7,520
10,000 - 15,000	7,122
15,000 - 20,000	5,459
20,000 - 25,000	3,269
25,000 - 40,000	2,657
40,000 - 100,000	696
100,000 and over	<u>92</u>
	37,668

Source: State of California Franchise Tax Board
Annual Report 1977

Per capita income has historically grown at a slower rate in Humboldt County than in California or nation-wide (QRC Research Corporation, 1978).

Community Demographics

Eureka, located on the central east side of Humboldt Bay, is the largest incorporated city in Humboldt County with a current estimated population of about 26,000 (Eureka Chamber of Commerce, 1979). Eureka is the county seat and a major commercial center providing basic services to persons throughout the county. Eureka has many restaurants, hotels, and motels, and a substantial tourist trade. Community and cultural events often center in the refurbished Old Town area near the waterfront.

Arcata, located on the northwestern side of Humboldt Bay, is a residential and commercial center with an estimated 1976 population of 12,050 (Arcata Chamber of Commerce, 1977). Arcata is the site of Humboldt State University with a 1978 academic year student population of 7,662 (HSU, Admissions and Records, personal communication). An estimated 62% of the student population make the Arcata area their home. The City of Arcata views the community as having planned growth that respects the value of prime agriculture and timberlands and the cultural diversity provided by resident millworkers, specialty craftsmen, businessmen, professional people, and students.

Residential communities of Bayside-Jacoby Creek, Indianola, Freshwater Corners, and Pigeon Point are located south along Old

Arcata Road-Myrtle Avenue between Arcata and Eureka. These communities are characterized by clusters of homes bordered by partly wooded hills on the east with agricultural bottom land and the Bay to the west.

The communities of Manila, Samoa, and Fairhaven are located on the North Spit. These communities are bordered by sand dunes to the west and the Bay to the east. Manila is a small, residential community with a few industrial lumber sites nearby. Samoa is a residential town owned by Louisiana Pacific Corporation and surrounded by pulp mill operations. Housing is provided for some lumber and pulp mill workers and their families (estimated 1970 population of 500). Fairhaven, a residential community of approximately 270 persons, is in close proximity to the Crown Simpson pulp mill. Fairhaven is the site of the historic community of Rolph. The U.S. Coast Guard station, near the end of the North Spit, has an estimated resident population of 80, including staff and families.

The Elk River bottomland is an area of mixed residential and rural housing. The drainage area had a 1970 estimated population of 3,000. Other communities south of the Elk River bottoms are King Salmon and Fields Landing with an estimated 1970 population of 805. King Salmon is located immediately south of Buhne Point on Humboldt Bay; it is a resort and residential community with tourist and recreational facilities such as charter fishing boats, docks and fishing access. Fields Landing is a residential community with lumber yards, fish and lumber docks, and a major boat building facility in the immediate area.

The Beatrice Flats and Table Bluff areas are rural with very small communities (Beatrice, Hookton, Indianola, and Southport Landing). Table Bluff is rich in history and contains the site of the last homes of the Wiyot Indians.

Outlying communities dependent on the study area for services and employment include the incorporated cities of Trinidad (population 550) and Blue Lake (population 1,850). Other residential communities include Westhaven-Moonstone, McKinleyville (population 10,000; Arcata Chamber of Commerce, 1979), Fieldbrook, Freshwater, and Humboldt Hill. To the south of Humboldt Bay there are numerous small cities and communities in the Eel and Van Duzen River basins dependent on the study area for services.

Community Attitudes

No public opinion survey was conducted as part of this study. Public input on the draft Humboldt Bay Wetlands Review and Baylands Analysis report is summarized in Volume III, Appendix F, Summary of Public Input.

3. Recreation

This section identifies existing recreational facilities in the study area and describes recreational activities in categories of water-related, active, and passive. Recreational facilities proposed or planned for the future are also identified and discussed.

The California Coastal Commission, North Coast Region, has identified 111 potential access points to the Bay; the number associated with any listing in this section is that assigned by the Coastal Commission. The California Department of Fish and Game identifies commonly used fishing and hunting sites in the study area; letters associated with a listing are for these sites (note that some of these sites correspond to California Coastal Commission access points and, therefore, are only numbered).

Existing Recreation Facilities

The following is a list of public and private recreational facilities and sites in the study area, including marinas, boat ramps, county and community parks and recreational areas, and U.S. lands; locations are shown on Plate 21. The numbers and letters are for site identification on the plate, the order of listing has no significance.

Recreational Facilities and Sites

Marinas:

- 75 Eureka Boat Basin
- 67 Woodley Island Marine (under construction; due for completion in 1981)
- 93 Johnny's Landing, King Salmon
- Q Pat's Landing, King Salmon

Boat Ramps:

- O Mad River County Park boat ramp
- 44 City of Arcata boat ramp
- 75 City of Eureka Boat Basin ramp
- P E-Z Boat Landing (hoist), King Salmon, private
- 93 Johnny's Landing (hoist), King Salmon, private
- Q Pat's Landing (hoist), King Salmon, private
- 102 Fields Landing County boat ramp
- 24 Samoa County boat ramp

Humboldt County Parks

- U Mad River County Park; a 91-acre site fronting both the Pacific Ocean and the Mad River.








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EXISTING RECREATION

PLATE NO 21 NORTH

LEGEND

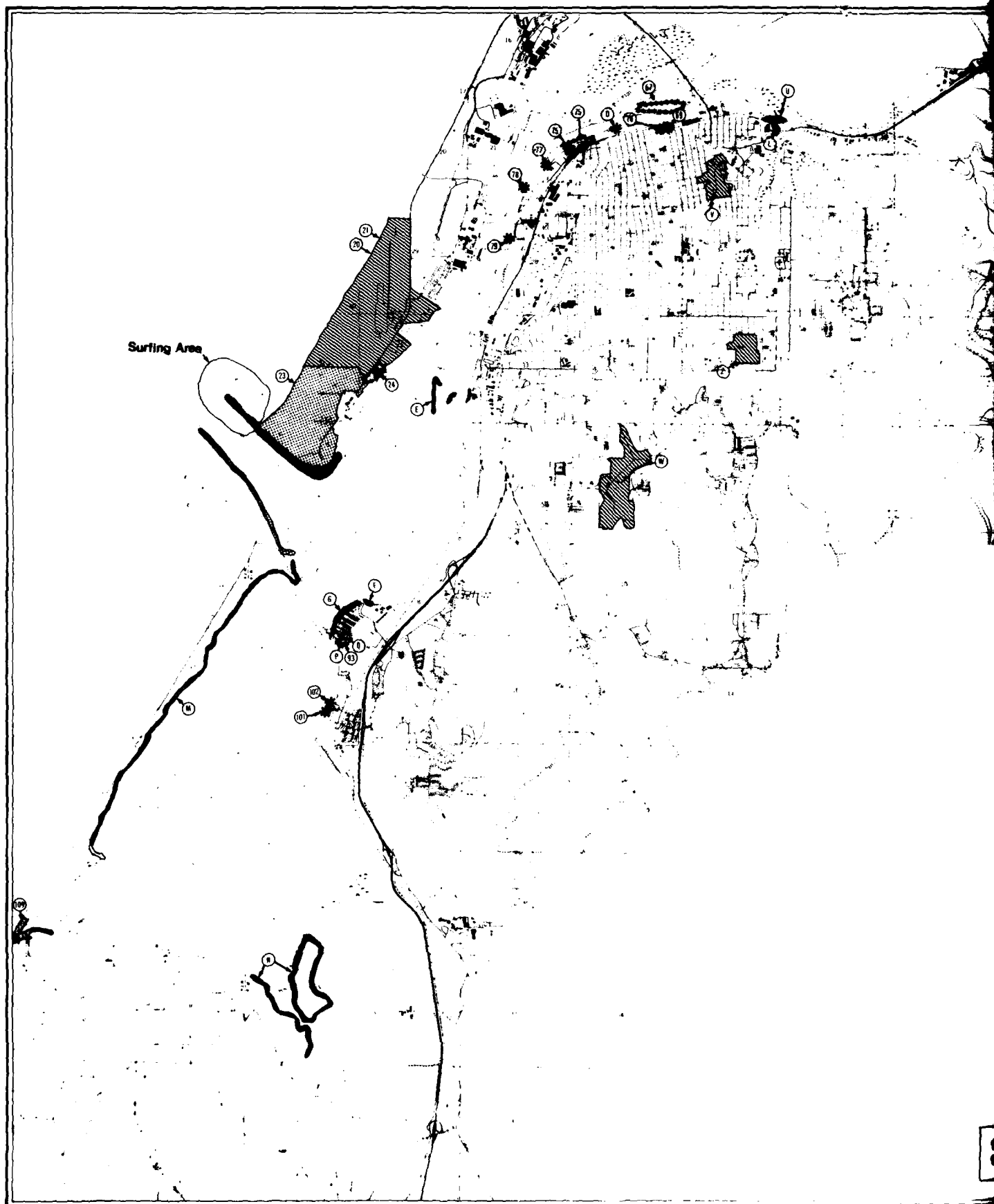
-  County Parks
-  Boat Ramps, Marinas
-  U.S. Public Land
-  City & Community Sites
-  Common Use or Access, DFG
-  Shoreline Fishing (excluding clamming)
-  * Shoreline Hunting

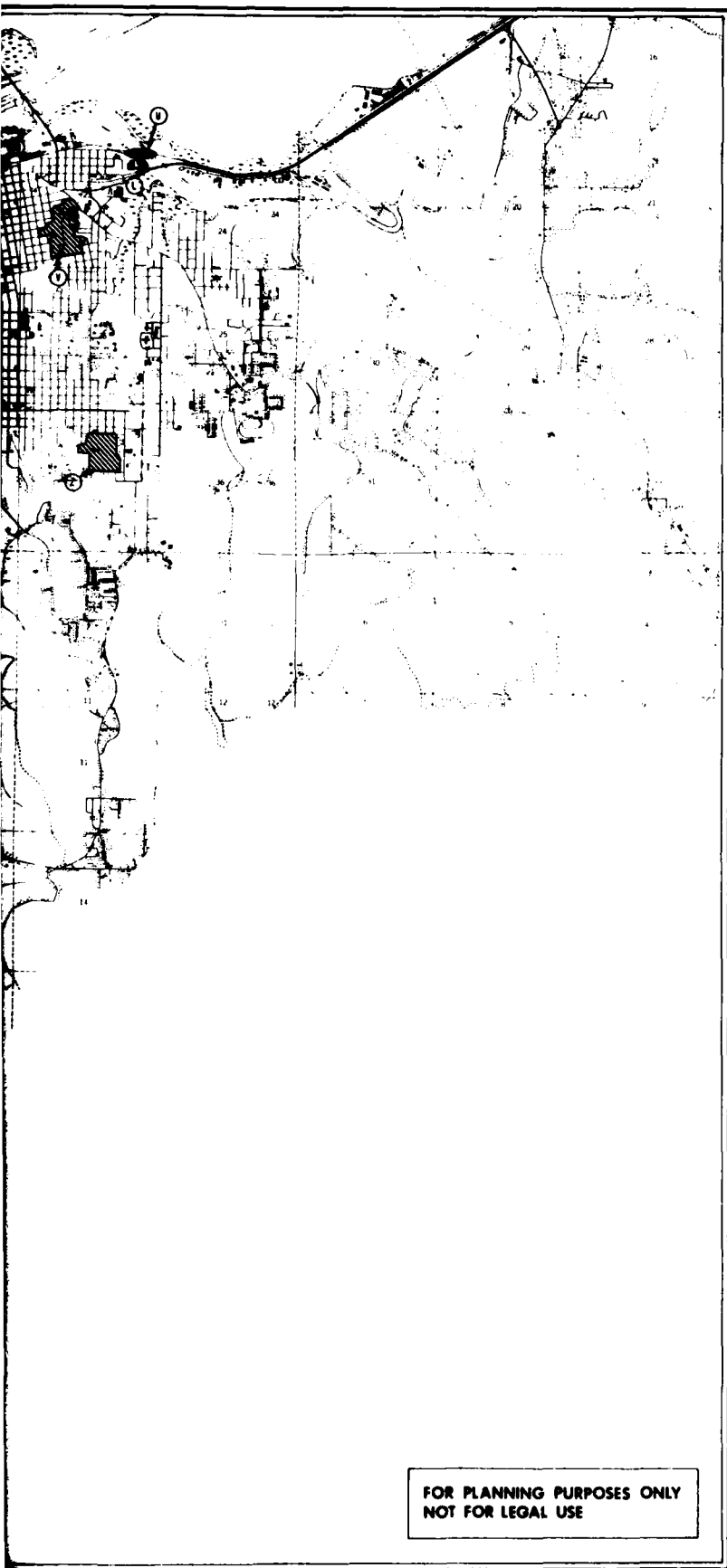


HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Calif Dept of Fish & Game
Calif Dept of Parks & Recreation
Humboldt County Trails Plan
Coastal Commission North Coast Region
Harbor District
City of Eureka Dept of Community
Development














EXISTING RECREATION

PLATE NO 21 SOUTH

LEGEND

-  County Parks
-  Boat Ramps, Marinas
-  U.S. Public Land
-  City & Community Sites
-  Common Use or Access, DFG
-  * Shoreline Fishing (excluding clamming)
-  * Shoreline Hunting



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Calif Dept of Fish & Game
Calif Dept of Parks & Recreation
Humboldt County Trails Plan
Coastal Commission North Coast Region
Harbor District
City of Eureka Department of Community
Development
City of Arcata Planning Department

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- 109 Table Bluff County Park; an approximate four-acre site at Table Bluff split between an overlook of the Pacific Ocean and Humboldt Bay, and the southernmost section of the South Spit.

U.S. Government Lands

- 23 Coast Guard Reservation, North Spit; covers the area at the south end of the North Spit.
- X Bureau of Land Management land, Arcata Bottoms; land borders the ocean and used as recreational site although access is limited.

City and Community Recreational Areas

- V City of Eureka Cooper Gulch Park; a 33-acre park site with playground and picnic area.
- W Eureka Municipal Golf Course, Elk River area; an 18-hole golf course.
- 20,21 Eureka Municipal Airport, North Spit; area considered a recreational facility for drag racing, ORV access, and recreational beach access. Outdoor sports events can occur at this site.
- 34 Manila Community Park, North Spit; area used as a residential park and play area.
- 79 City of Eureka fishing dock, foot of Del Norte Street, Eureka; used for dock fishing and crabbing.
- Z Sequoia Park, including a zoo, playgrounds, a concert area and areas for walking.

Recreational Activities

Water-related Recreation. Water-related recreational activities in the study area include sport fishing, waterfowl hunting, clam digging, crabbing, sailing, small craft boating, surfing, and skin-diving. Sites commonly used for water-related recreational activities are described for each activity.

Sport fishing access to Humboldt Bay is by boat or skiff launched from the previously listed boat launch facilities. Sport fishing is also conducted from shore and dock areas and by skin-diving. Although all of the commercial docks in Eureka and Fields Landing are used for sport fishing, fishing success is greater at the more commonly used sites. The following is a list of more commonly used sport fishing docks and shore sites in the study area as identified by the California Department of Fish and Game.

- 40 Mad River Slouth Bridge, Lamphere Road
- A, B Mad River Slough Bridge, Highway 255; Samoa boulevard
- CC Eureka Slough railroad bridge, Eureka
- 70 Humboldt Seafood, Inc. dock, foot of J Street, Eureka
- DD Lazio's Sea Foods dock, foot of C Street, Eureka
- 77 Washington Street pier, Eureka
- 78 City of Eureka dock, foot of DelNorte Street
- E Elk River Spit, mouth of Elk River
- F PG&E power plant thermal outfall, King Salmon
- G Buhne Point Jetty, King Salmon
- 102 Eureka Fisheries, Inc. dock, foot of C Street, Fields Landing
- 111 South jetty and sea wall, shore fishing and skindiving
- H North jetty, shore fishing and skindiving
- 24 Samoa County boat ramp
- North and South Spit beaches and Mad River beach, surfcasting and netting

The banks of both sides of the Mad River, except where access is impossible, are used for salmon and steelhead fishing.

Hunting for waterfowl is conducted on the bay, sloughs, marshes, and agricultural lands. Hunting is conducted by using boats, sculling in a low profile skiff, walking along levees, and using temporary or permanent blinds along the shoreline. Most hunting blinds and skiff launch sites are located on private property. Sites commonly used for hunting access, identified by California Department of Fish and Game, other than the previously listed boat ramps, include, but are not limited to, the following:

- 40 Mad River Slough Bridge, Lamphere Road
- 37,38 Mad River Slough Bridge, Highway 255, Samoa Boulevard
- I Bayview levee, between Mad River Slough and McDaniel Slough
- 44 City of Arcata landfill dump
- J City of Arcata oxidation ponds
- 47 Bracut Lumber Yard levee
- 46 Marsh Area at mouth of Jacoby Creek
- 48 Mouth of Fay Slough at Brainard

- K Marsh area north of Highway 255 Samoa Bridge, east of Northwestern Pacific Railroad tracks
- L Eureka Slough via Montgomery Wards' parking lot, by permission only
- M South Spit area, east of South Jetty Road
- N Hookton Slough levee

Clamdigging access is by foot along the South Spit, by boat launch from a ramp, or by skiff launch off the point of the South Jetty sea wall. Sport crab pots and rings are set off of the King Salmon area or attached to docks and pilings around the bay. Sport charter boats dock in the King Salmon area and tour boats dock at the foot of C Street, Eureka. Sailboats and other small craft use the boat ramps identified above. The wave sets directly west of the North Jetty are used for surfing. Skindiving, mostly for sport fishing, occurs close to the rocks on the inside of the South Jetty and sometimes on the inside of the North Jetty during calm weather and slack tide.

Active Recreation. Active recreational activities include bicycling, jogging, and horseback riding. Jogging occurs throughout the study area, but predominantly in the Arcata bottoms and on the North and South Spits. The Six Rivers Running Club has a large membership and organizes frequent local events. Horseback riding occurs on the Mad River beach, North Spit, South Spit, and Elk River Spit.

The use of off-road vehicles (ORV) is popular in the area. ORV enthusiasts use the Mad River beach and dunes, and the North and South Spit beach and dunes extensively. Access for ORV use is from any road end or passible area to the beach and dunes. There are plans under consideration for the Humboldt County Local Coastal Program that would restrict ORV access in the future.

Passive Recreation. Passive recreational activities in the study area include nature walks, picnicking, day camping, hiking, and sightseeing by car. Nature walks include bird-watching and beach-combing for shells, rocks and driftwood. Areas used for passive recreation include the county parks and city and community recreation areas. The Mad River beach area, the North Spit and Jetty, South Spit and Jetty, Table Bluff area, and Elk River Spit are used extensively for passive recreation. In addition, the Arcata bottoms, the Arcata oxidation ponds, and the landfill areas are used for bird watching. The Highway 255 Samoa Bridge is open on Sundays to pedestrian traffic, allowing an excellent view of the islands and surrounding bay.

Proposed Recreation Facilities and Sites

The following proposed recreation sites and facilities are shown on Plate 22.

The City of Arcata and the California Coastal Conservancy have proposed a Marsh Enhancement Project on a 63-acre site on Humboldt Bay between Janes and Jolly Giant Creeks. The project includes a recreational lake for bank fishing and passive recreation and a picnic area. The project is scheduled to begin by September 1979 and may be completed by 1980.

The City of Eureka has proposed a waterfront park and access points as part of the Tideland and Waterfront Plan. The plan area covers 102.3 acres extending along the Eureka Waterfront from Commercial Street on the west to the intersection of the shoreline and the Northwestern Pacific railroad on the east. At least three park areas are proposed. A waterfront boardwalk may be constructed.

Humboldt County has proposed a tentative County Trails Plan for bicycling, horseback riding, and hiking. There are nine proposed community trails in or near the study area. Five of the trails are bikeways along existing roads. Proposed trails that require some construction within the study area are as follows:

- 30 Mad River beach; a horse, hiking, and bike trail
- 32 Bayview Levee, Arcata; a hiking trail
- 43 Elk River Spit; a hiking and horse trail.

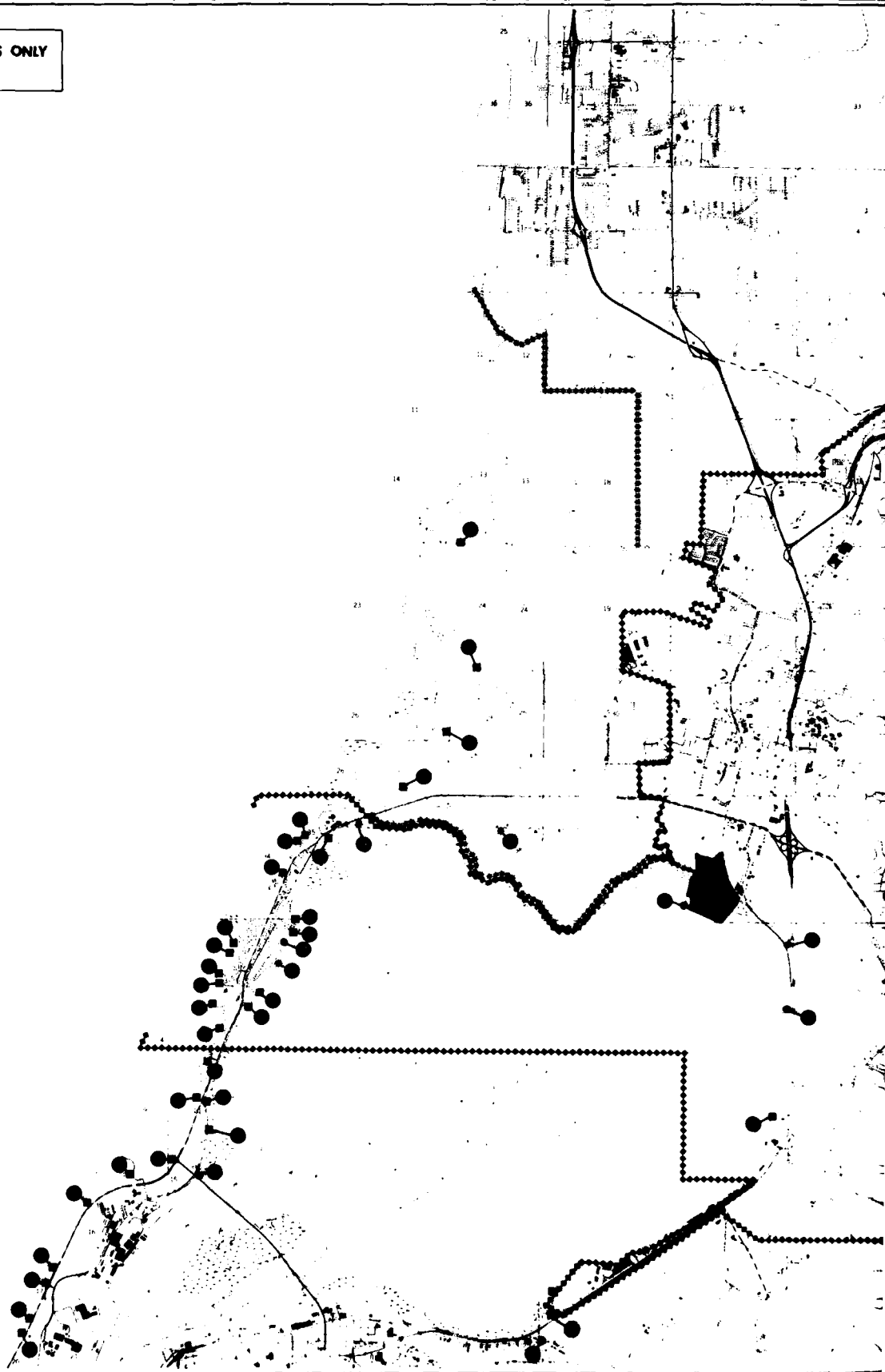
In addition, the County has proposed a State bike route along Highway 255-Samoa Boulevard.

The California Department of Parks and Recreation has a proposal to create a South Humboldt Bay State Park, which would include all of South Bay, most of Beatrice Falts, and part of Table Bluff. However, no funds have been set aside for acquisition and the proposal is not in a very active state (Hangola, 1979, personal communication). The area is not designated as a recreation program area.

Potential Shore and Water Access Points

The potential access points identified by the California Coastal Commission, North Coast Region, are shown on Plate 22. The 111 points are broken out as in private ownership (66 sites), public ownership (22 sites), or mixed public and private ownership (23 sites). This last category includes areas such as public roadway ends surrounded by private lands. Ownership status is as identified by the Coastal Commission. A description of each point, including shoreline uses, natural environment, public safety, existing and lateral access, existing parking, land use, local roadway access, mass transit, and

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POTENTIAL RECREATION

PLATE NO 22 NORTH

LEGEND

----- North Humboldt PRD

----- Proposed Trails

■ Proposed Marsh

Potential Access

■ Private

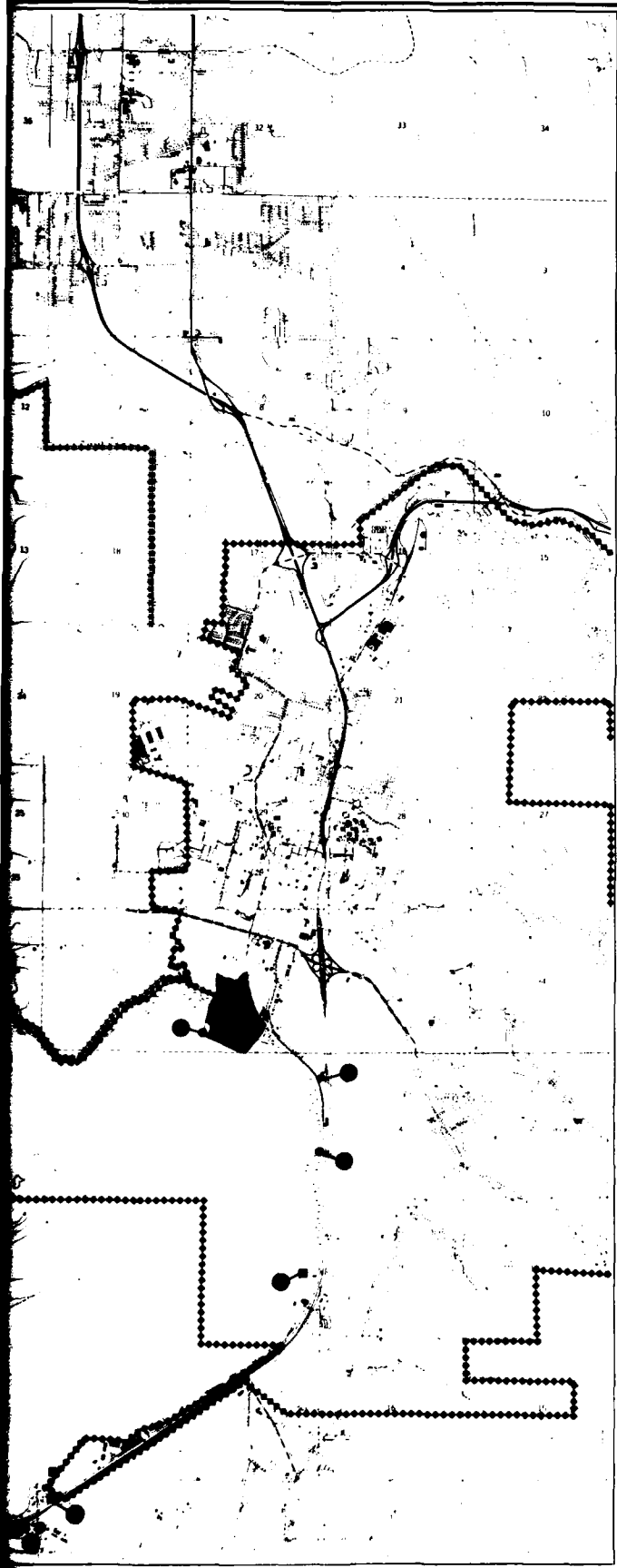
● Public

● Public/Private



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Calif Dept Fish & Game
Calif Dept Parks & Recreation
Humboldt County Trails Plan
Coastal Commission North Coast Region
Harbor District
City of Eureka Department of Community
Development
City of Arcata Planning Department





POTENTIAL RECREATION

PLATE NO 22 SOUTH

LEGEND

◆◆◆ Proposed State Park (1971)

----- Proposed Trails

■●* Park -
Proposed Waterfront

Potential Access

■ Private

● Public

* Public/Private



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Calif Dept of Fish & Game
Calif Dept of Parks & Recreation
Humboldt County Trails Plan
Coastal Commission North Coast Region
Harbor District
City of Eureka Department of Community
Development
City of Arcata Planning Department

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trail access, can be obtained from the Coastal Commission. The inventory of identified potential access points is intended for discussion purposes only, as many of the points may conflict with agriculture, habitat, or other uses or private property rights.

As part of their Local Coastal Program efforts, the City of Arcata and Humboldt County have prepared draft reports on shoreline access issues and access points. The drafts were available in March 1979 and are summarized below.

Arcata. The City identified existing principal access points as follows:

- . Pedestrian access: along the dikes west from McDaniel Slough, at the City's boat ramp and abandoned landfill site, south from the City's oxidation pond, and along South G Street.
- . Vehicular access: at the City's boat ramp and at a station maintained by the Humboldt Bay National Wildlife Refuge (restricted to research or educational activities).
- . Boating access: at the City's boat ramp and sometimes from the Mad River Slough area.

Of the principal access points, the City's boat ramp is the most convenient (and the only legal point, according to Arcata's draft report).

Arcata's draft identifies and evaluates three potential access corridors: I Street from Samoa Boulevard; a greenbelt park along McDaniel Slough from Zehnder Avenue to the Bay (proposed in the City's Park and Recreation Master Plan); and along South G Street into the marshes as far south as Gannon Slough. The City concluded that of these three, I Street was the most feasible and should be designated as the major public access corridor to the Bay. South G Street should be designated a secondary access corridor to be developed only in conjunction with improved access to the Wildlife Refuge.

Humboldt County. Humboldt County has identified several critical access issues for the Humboldt Bay study area, as follows:

- . North Spit access is informal and near-shore parking along the spit is probably inadequate for increased use.
- . Potential areas for formalized access include the County landfill site at Table Bluff, the Elk River spit, and lands adjacent to the railroad right-of-way between Arcata and Eureka.

- . No policy exists to assure adequate access through new development.
- . Access to the Mad River is adequate but not well posted.

The County draft report does not identify any specific public access points in the study area, but relies on the material developed by the Coastal Commission, North Coast Region. The draft report indicates that of 40 miles of Bay shoreline, only three miles are in public ownership (owned by the Coast Guard, Eureka, and Arcata). The access points identified by the Coastal Commission (see above) will be considered in the County Local Coastal Program effort. This effort must also address limitations to access such as parking, road capacity, use conflicts, environmental considerations, public safety, and conflicts with agriculture. To the extent that access is inadequate because of non-existent or limited accessways, then (1) access will be required of new development, (2) public prescriptive rights to protect existing informal access will be asserted, and/or (3) improvements to support facilities may be required.

4. Educational and Scientific Uses

There is extensive use of the Humboldt Bay study area for educational and scientific purposes by various groups.

The Humboldt County Schools Environmental Education Program supplies many project activities for teachers of grades 1-8, which include overlays, manuals, field trip materials, and taped tour programs. Humboldt Bay areas used for field trips commonly and frequently are as follows:

- Arcata boat ramp
- Arcata oxidation ponds and adjoining marsh area
- North Spit and Jetty, virtually in its entirety
- South Spit and Jetty
- Eureka waterfront and Old Town
- Table Bluff
- Humboldt Hill

Boat tours of Humboldt Bay are arranged on a charter basis and the individual teacher designs specific aspects of the bay to investigate. Ecology and habitat flora and fauna presentations are made during field trips that stop at marsh areas around the bay. There are only a few high schools throughout the county that are in the environmental education program. Therefore, educational use of the bay by grades 9-12 depends on programs designed by individual teachers.

The School of Science, the School of Natural Resources, and other departments of Humboldt State University use Humboldt Bay and its environs extensively. The area is considered an outdoor laboratory. Areas consistently used for investigation and field trips include, but are not limited to, the following:

- Arcata oxidation ponds and adjacent areas
- Arcata bottoms
- Mad River Slough marsh area
- Lanphere-Christensen Dune Reserve
- Marsh area along Highway 101 between Arcata and Eureka
- Eureka, Fay, and Freshwater Sloughs and marshes
- Elk River Slough and spit
- Buhne Point Jetty
- Table Bluff
- South Spit and Jetty
- North Spit and Jetty
- Waters and mudflats of the entire Bay including North Bay, Middle and Entrance Bay, and South Bay.

Field course work in oceanography, fisheries, wildlife biology, zoology, and botany includes sampling design and use of equipment, collection and identification of flora and fauna, physical field observations, and data analysis techniques. Research use of the study area by Humboldt State University is predominately restricted to graduate student theses. A few faculty seek research grants or subcontract research, but funding sources are limited. No extensive multi-disciplinary surveys have been conducted.

College of the Redwoods, a community junior college, has various departments that conduct field trips to Humboldt Bay. Sites are similar to those of Humboldt State University, but use frequency is lower.

The local chapter of the Audubon Society conducts bird field trips to various habitat areas surrounding Humboldt Bay. The Sierra Club conducts outings for ecological study and pleasure. Some areas frequently used for these purposes are:

- Lanphere-Christensen Dunes Reserve
- Arcata oxidation ponds
- Mad River Slough area
- Coast Guard Station dune and spit area
- North Jetty
- Table Bluff
- South Spit
- South Jetty

5. Refuges and Reserves

Plate 23 shows the location of existing and proposed refuges and reserves in the Humboldt Bay Wetlands area.

The Lanphere-Christensen Dunes Reserve, located off Lamphere Road between the Mad River Slough and the Pacific Ocean, is owned by the Nature Conservancy and managed by Humboldt State University. The reserve covers 133 acres including the 80-acre addition proposed to the north. The dune reserve is of high ecological value and an important wildlife and plant study area.

The Woodley Island Wildlife Habitat area, covering approximately 25 acres, has been created as part of the Woodley Island Marina Project. The area has been set aside as a wildlife and plant reserve that will be used for educational, scientific, and research purposes on a controlled basis. The boundary of the area is to Mean Higher High Water.

The Humboldt Bay National Wildlife Refuge has been authorized by the Migratory Bird Conservation Commission and will be managed by the U.S. Fish and Wildlife Service. The refuge boundaries, as approved, encompass approximately 7,814 acres in five separate units: South Bay, Indian Island, Sand Island, Jacoby Creek, and Eureka Slough. Exact acreage may change in the property acquisition stage. The refuge will protect key wildlife habitat associated with migratory birds, fish nursery grounds, shellfish, and marine life. A principal objective will be the restoration of the Bay as a black brant wintering area. About 550 acres of diked pasture may be ultimately returned to salt marsh or fresh ponds. Human benefits include maintaining natural and open space and recreation activities. As of 9 April 1979, only 130 acres of the approved area had been acquired; the acquired lands are in the Jacoby Creek and Eureka Slough units. Some acreage in South Bay is under option. The refuge expects funding for land acquisition in Fiscal Year 1981-82.

State Clam Reserves were established in Humboldt Bay under Section 6497 of the California Fish and Game Code (changed to Section 6483 in 1971). These reserves are areas of native clam habitat. The reserves are referred to as Public Clamming Areas; they are open for sport harvest of clams by the public. According to a memorandum from the Marine Resources Branch of California Department of Fish and Game, 13 March 1979, these reserves may not now be valid, as the Fish and Game Code says they may be established on "state tide and submerged lands" (Section 6483, California Fish and Game Code, 1975). Several of the clam reserve areas are now part of the area granted to the Humboldt Bay Harbor Recreation and Conservation District. The two agencies are resolving this apparent conflict. In addition to the specific reserve areas outlined on Plate 23, the entire South Bay is considered a Public Clamming Area.

There are also two native oyster reserves in Humboldt Bay, both located in North Bay.

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This is a high-contrast, black and white map of a city, likely Tokyo, showing a dense network of streets and buildings. The map is oriented vertically, with the city center at the top. A prominent, dark, irregular shape, possibly a large building or a park, is visible in the lower-left quadrant. The map is framed by a thick black border.

Humboldt Bay Wildlife Refuge

Humboldt Bay Wildlife Refuge

Approved

 **Acquired**

Lanphere-Christensen Dunes

Proposed

Woodley Island Habitat

Shellfish Reserves

Native Oyster

Clams



Source US Fish & Wildlife Humboldt Bay National
Wildlife Refuge
Calif. Fish & Game
Nature Conservancy
Harbor District



REFUGES/RESERVES

PLATE NO 23 SOUTH

LEGEND

Humboldt Bay Wildlife Refuge



Approved



Acquired



Woodley Island Habitat

Shellfish Reserves



Native Oyster



Clams



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: US Fish & Wildlife Humboldt Bay National
Wildlife Refuge
Calif Fish & Game
Nature Conservancy
Harbor District

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B. AESTHETIC PROFILE

This profile consists of three parts, beginning with a summary of existing policy planning, moving on to a factual description of the study area, and then ending with an evaluation of the visual sensitivities in the Humboldt Bay planning area.

1. Existing Coastal Policy and Local Policy Planning

California Coastal Act

The California Coastal Act requires protection of visual quality in the coastal zone. The Act spells out policies for the "protection and enhancement" of coastal visual resources in two sections of the Coastal Act's third chapter. These are:

Section 30251. "The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to maximize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas. New development in highly scenic areas such as those designated in the California Coastline Preservation and Recreation Plan prepared by the Department of Parks and Recreation and by local government shall be subordinate to the character of its setting."

Section 30253. "New development shall: where appropriate, protect special communities and neighborhoods which, because of their unique characteristics, are popular visitor destination points for recreational uses."

California Coastal Guidelines

The California Coastal Commission, in May of 1977, adopted the following guidelines as informal assistance in further defining the policies of the Act. These guidelines have been summarized in a draft Visual Resource Protection Report for the Humboldt County Local Coastal Program and are included below:

"The primary concern under this section of the Act is protection of ocean and coastal views from public areas such as highways, roads, beaches, parks, coastal trails and accessways, vista points, coastal streams, and water used for recreational purposes,

and other public preserves rather than coastal views from private residences where no public vistas are involved."

These policies can be broken down into specific focuses. First, it can be seen that there is a distinction in policy for "coastal areas" (generally all lands in the Coastal Zone) and for "scenic coastal areas" (which consist of the Pacific Ocean; "highly scenic areas" especially where these have been designated by a state or local agency; and "special communities and neighborhoods" as defined in the LCP Manual).

For "coastal areas" the policies of the Act are to:

1. Protect view to "scenic coastal areas" including the Ocean.
2. Minimize alterations to natural land forms (i.e., extensive grading, filling, dune removal, etc.).
3. Keep new development "compatible" with its setting.
4. Restore "visually degraded areas."

For "highly scenic coastal areas" there are two additional policies to:

1. Keep new development "subordinate" to its setting.
2. Protect unique characteristics of special communities that are "popular visitor destinations for recreational users."

California Coastal Manual

The State Coastal Commission has also adopted a planning manual to assist local government in preparing Local Coastal Programs as required by the Act. This manual provides more specific guidance in defining Coastal terms. The following is a distillation of the appropriate sections of the manual as referenced by the Draft Visual Resource Protection Reports.

"Special Communities and Neighborhoods" include the following:

1. Areas characterized by a particular cultural, historical, or architectural heritage that is distinctive in the coastal zone.
2. Areas presently recognized as important visitor destination centers on the coastline.
3. Areas with limited automobile traffic that provide opportunities for pedestrian and bicycle access for visitors to the coast.

4. Areas that add to the visual attractiveness of the coast.

"Highly Scenic Areas" generally include:

1. Landscape preservation projects designated by the State Department of Parks and Recreation in the California Coastline Preservation and Recreation Plan.
2. Open areas of particular value in preserving natural landforms and significant vegetation, or in providing attractive transitions between natural and urbanized areas.
3. Other scenic areas and historical districts designated by cities and counties.

City of Eureka

The City of Eureka has included several similar policies in its General Plan that reflect the policies of the Coastal Act. The following are some brief excerpts of the City of Eureka General Plan, Scenic Route Element, 1976:

"Eureka's ultimate goal in regard to scenic quality is the creation of a visually pleasing, safe, and economically healthy community in which the natural and people-made environmental qualities of the area are retained and enhanced. Movement towards this goal should include a functional scenic route network for pleasurable driving and riding throughout the community. Inherent in the implementation of the overall goal is the establishment of community awareness and pride of the historical heritage and natural assets of the region, protection of scenic views observable from scenic routes, and diversifying and upgrading the economy of Eureka."

The primary scenic routes identified in the Scenic Route Element, City of Eureka General Plan, are listed in Table VIII-2.

City of Arcata

Arcata, the second and smaller city in the area, has presented some more specific policies and regulations, including design review as one means of planning for the visual resources. The following is summarized from Arcata's LCP Visual Resources and Special Communities Report, 1979:

The major coastal visual resources of the Arcata city limits and the Arcata Coastal Zone are the Bay and its environs and the agricultural lands to the south and west of the city. Billboarding

Table VIII-2

EUREKA SCENIC ROUTES*

Route	Scenic Features	Necessary for Implementation
Existing Highway 101 from King Salmon Exit to Elk River Road	Fishing town's view of Bay and Ocean; pasture land	Maintain rural character; encourage billboard removal; bicycle lane desirable; relocate or eliminate utility poles
The adopted Eureka Freeway, from Elk River Road to Eureka Slough	Eureka townscape; landscaping	Varied landscape; vista points desirable; bicycle lane desirable; relocate or eliminate utility poles; implement freeway and core acre development design proposals
Highway 101 from Eureka Slough to Bayside Cutoff	Bay; Slough; pasture land; trees and mountains	Screen existing non-compatible commercial; encourage billboard removal; provide vista points; maintain agricultural; relocate or eliminate utility poles; provide bicycle lane right-of-way; retain natural landmarks; retain eucalyptus trees
Highway 255	View of Bay and islands; dunes and native vegetation	Retain natural characteristics
Elk River Road from Highway 101 to Ridgewood Drive	Pasture land; pleasing view of homes	Improve pavement; maintain rural density
Ridgewood drive from Elk River Road to Walnut Drive	Rural farm atmosphere; view of Elk River Valley; Bay and Ocean	Improve pavement; maintain rural density; vista point desirable
Walnut Drive from Ridgewood Drive to Campton Road	Gulches and forest trees	Maintain rural density
Fairway Drive from Oak Street to Herrick Road	Trees; golf course; open space and large lots	Maintain present characteristics of area
Herrick Road from Fairway Drive to Elk River Road	View of Bay; rural; residential	Relocate or eliminate utility poles; improve pavement
Old Arcata Road from Bayside Cutoff to Freshwater Corner	Farm land; waterways; trees; view of mountains	Bicycle lane desirable; relocate or eliminate utility poles; screen commercial areas; maintain farm land

* Eureka Department of Community Department (1975); City of Eureka General Plan, Scenic Route Element; Eureka California; March, 1976

Table VIII-2 (Continued)

Myrtle Avenue from Freshwater Corners to Hall Avenue	Trees, waterways, farm land, open area	Bicycle lane desirable; maintain farm land and rural densities
New Waterfront Drive along the Railroad right-of-way from "Y" Street to Wabash Avenue	View of Bay, marinas, historic sites	Implementation of the Core Area Development Plan
Second Street from "E" Street to "B" Street	Visual amenities of Eureka historical value and present urban form	Design criteria outlined for the Core Area Development Plan such as street lighting, traffic signs and signals, street planting and paving materials; general guidelines for citizen participation in the implemen- tation of route beautification
Third Street from "E" to "G" Street		
"O," Third and "P" Streets bordering the site of Carson House		
"E" Street from the New Waterfront Drive to Huntoon Street		
Shorter scenic routes off "B" Street as shown on Map A		

as practiced along Highway 101 is a major visual problem and is almost certainly in conflict with Coastal Act policies. Arcata attempted to deal with the billboard issue with the adoption of the City's Land Use and Development Guide in 1976. It permits signs designed to be read from any State expressway only in Thoroughfare Commercial or Industrial zones. The billboards along Arcata Bay are non-conforming uses and must be removed in 1981. This portion of the Guide has been challenged in court by sign owners and final disposition of the signs is not yet known. Along South I Street and South G Street, the visual attractiveness of the area is severely reduced by the presence of scattered industrial debris and the old Arcata dump site. The dump site will be reclaimed through creation of marshes, a freshwater lake, and wildlife habitat areas.

The primary scenic routes identified by the City of Arcata in the Coastal Zone are listed in Table VIII-3.

Humboldt County

The scope of work completed on visual resources throughout the Humboldt County Coastal Zone is outlined in the Draft Visual Resource Protection Report, 1979. The draft report identifies areas of specific visual importance such as viewpoints surrounding Humboldt Bay. These viewpoints are described further on in this profile.

Additional Viewer Characteristic Studies

The local and regional Coastal Commission staffs have been studying the characteristics of viewers in order to help them develop visual protection policies. This study is very interesting and adds some insight into the nature of land use planning conflicts in the region between tourists and residents. They have identified four categories of viewers: (1) Tourist/Recreationist, (2) Tourist/Drive-through, (3) Resident/Recreationist, and (4) Resident Householder.

2. Description of the Planning Area

The Coastal Commission and local planning staffs have concentrated their efforts to date on identifying "Viewpoints and Viewsheds" from where people can achieve an unobstructed view of the Bay and environs. These viewpoints are reviewed further on in this profile. In addition to specific viewpoints, it is also important that visual resource planning be conducted within a broader framework that includes all of the planning area such as by dividing the area in Landscape Types.

Table VIII-3

ARCATA SCENIC ROUTES WITHIN THE COASTAL ZONE*

<u>Route</u>	<u>Scenic Features</u>	<u>Desirable for Implementation</u>
Old Arcata Road from the 7th Street overcrossing to Crescent Drive	Pasture land, eucalyptus trees, all density devel- opment, curving roads	Development on the west side of Old Arcata Road should be limited to single family homes or structures of low elevation which would not block view. Eucalyptus trees lining Old Ar- cata Road should be retained.
Bayside Cut-off from Highway 101 to Old Arcata Road	Open Space	Maintain agricultural
4th Street from Sunnybrae north to town	Pasture land	Maintain agricultural, allow- ing for large lot development or cluster housing.
Highway 255 from "V" Street to Manila	Agricultural, dunes and view of the Bay	Maintain agricultural
Janes Road from 11th Street o Simpson Mill	Pasture land, pleasing view of homes	Develop in single story senior village.
Highway 101 to Mad River area	Landscaping	Utilize natural vegetation for landscaping. Vegetation should not overhang freeway right-of-way. Encourage bill- board removal and keep the area between the highway and the Bay open.

*from Appendix K: Arcata Scenic Routes. Arcata General Plan, 1975.

Landscape types or "representative landscapes" are recurrent settings within the entire Humboldt Bay region. Major landscape types are areas in which a person can anticipate similar characteristics and experiences. These areas are based upon broad similarities in landform (topography) and landcover (i.e., water, vegetation, and types of land use).

Within the Humboldt Bay region six major landscape types have been identified and are listed below. The land use subareas identified in the Land Use Profile (Section VII) are each related to a specific landscape type.

Landscape Type No. 1 - Water Areas

The water surface within Humboldt Bay is the primary visual focus which provides the unifying image of the entire Bay. Three major water surface areas having distance visual characteristics are: (1) North Bay, (2) Middle Bay, and (3) South Bay. The primary visual characteristics of the North Bay are its relative large circular size and extensive mud flats, as well as its open and spacious feeling. The long and relatively narrow configuration of the Middle Bay, its islands, urban and industrial fringe all combine to convey a busy and dynamic man-made image. Although South Bay is similar in shape and spaciousness to North Bay, it is smaller with a more natural character. The other major water surface of visual significance from North and South Spit is, of course, the Pacific Ocean.

Landscape Type No. 2 - Coastal Dunes

The coastal dunes of Humboldt Bay share a common and distinctive visual image in terms of their sandy and vegetative character. Three major dune areas can be identified: (1) North Spit, (2) South Spit, and (3) North Dunes (the extreme western edge of Arcata Bottoms subarea). North Spit is readily accessible by auto and is characterized by extensive residential and heavy industrial use. Visual access to the Bay and to the Ocean from the main highway is limited because of existing development as well as from the fact that the height of the dunes prevents viewing the Bay or Ocean from the roadway. South Spit contrasts visually with North Spit in lacking any development, having lower dunes, and a much greater open and spacious character. The North Dunes, unlike North and South Spit, has a greater degree of bare sand dunes and is relatively inaccessible by auto as well as being bounded on the east by lowlands (Arcata Bottoms) instead of the Bay.

Landscape Type No. 3 - Lowland

The lowland areas abutting Humboldt Bay contribute a very important sense of visual open space and pastoral character and are distributed around the Bay in such a manner as to provide an interesting and diverse sequential driving experience between the cities

and towns along Highway 101 and Samoa Road. There are five lowland areas. The areas of Arcata Bottoms (1) and Beatrice Flats (2) retain much of their open pastoral quality. Open Space lowland areas remain within Bayside Bottoms (3), Eureka Slough (4), and Elk River (5), but these areas are undergoing a variety of development.

Landscape Type No. 4 - Uplands

The upland areas on the east and south sides of Humboldt Bay form a visually important backdrop from the main highways around the Bay. These uplands, which include Humboldt Hill, part of the city of Eureka, and areas east of Bayside and Arcata, are heavily wooded and maintain their forested character despite residential development. Table Bluff offers a distinctly different visual character with its grasslands, open visual character and sweeping views over South Bay.

Landscape Type No. 5 - Urban

The urban areas surrounding Humboldt Bay are comprised of a variety of residential, commercial, and industrial uses. The two cities of primary visual significance are Eureka and Arcata. Eureka, with its extensive urban waterfront, is particularly visually significant and is increasing its visual access to the Bay within its historical district. Other towns having visual access to the Bay are Manila, Samoa, and particularly King Salmon and Fields Landing.

Landscape Type No. 6 - Gulches

The gulches in the study area are a visual transition between lowlands and uplands and are primarily located in the Elk River and Eureka subareas. Gulches are usually open space, passive recreational areas, often planned as greenbelt areas.

3. Evaluation of Landscape Characteristics

The visual characteristics of the landscape can be evaluated in two ways. The first is an evaluation of the most important viewpoints, places from which to view the landscape; while the second evaluates the overall landscape type and its relative sensitivity to development.

Viewpoints

The Coastal staffs, both state and local, have conducted an inventory of the important viewpoints. These viewpoints have been reviewed and do provide significant views of the surrounding landscape. These are shown on Plate 24 as lettered points and are described briefly below according to the landscape type within which they are located. Other scenic views and features have been identi-

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AESTHETICS

PLATE NO 24 NORTH

LEGEND

Viewpoints

(X) Coastal Commission

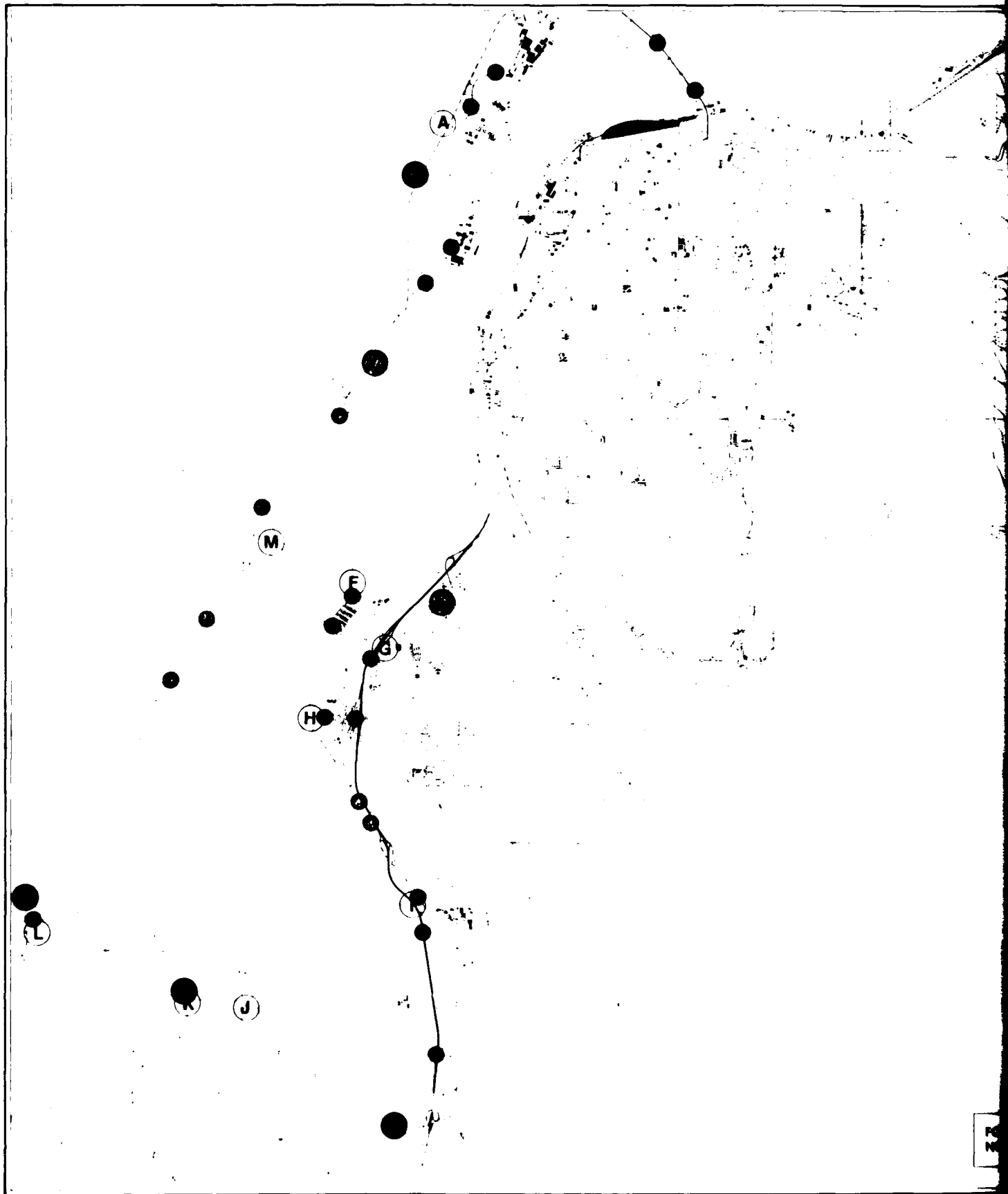
● Consultant



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Calif Coastal Commission North Coast
Region





AESTHETICS

PLATE NO 24 SOUTH

LEGEND

Viewpoints

⊗ Coastal Commission

● Consultant



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Calif Coastal Commission North Coast
Region

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fied by the cities of Eureka and Arcata (Tables VIII-2 and VIII-3). The consultant has identified significant views (shown on Plate 24) around the Bay. Views from points along Highway 101 between Eureka and Arcata, particularly near the Bracut and Brainard sites, are partly blocked by development and/or billboards. Views along the North Spit near Samoa include industrial development.

Lowland Landscape Type. Within the Bayside Bottoms, only the area marked "E" (Plate 24) has been identified as providing a view of the Bay from Highway 101 on county lands. This area is interrupted by several large billboards and a lumber yard. To the east along this section immediately adjacent to the highway, the generally rural/open space character of the Bayside Bottoms is interrupted by a Department of Highways maintenance yard, a lathe mill, burl shop, and RV campground, all in close proximity. In the middle distance a prominent row of metal towers supporting high tension lines parallels the road.

Other areas in the lowland landscape type are Points G (Elk River) and I (Beatrice Flats). From these points along Highway 101, views are obtained of the South Bay and South Spit. Scattered billboards in both areas raise questions on the proper control of outdoor advertising west of the highway. Diked agricultural lands south and west of Viewpoint I provide attractive open space views on lands not suited to more developed uses.

Coastal Dune Landscape Type. Within the North Spit area, the following viewpoints have been identified by the Coastal Commission: Point D at the bridge over Mad River Slough; Point C on the mudflats south of Manila; and Point B on the Old Samoa Road at the foot of Samoa Bridge. All of these viewpoints serve many uses, including hunting and boating access, of Resident/Recreationists. All enjoy views of the Bay, with distant views of the major islands. All are areas with some development.

Also, within North Spit is the area adjacent to Point A which provides views to the Ocean and dune areas which are regularly used by Residents/Recreationists. Directly east of this area is the major heavy industrial zone at and south of Samoa, parts of which are visible from portions of the beach. While this may detract somewhat from the "natural" quality of the beach viewshed in this area, it is still regularly used by residents.

Within the South Spit area virtually all points on the Spit offer views of the Bay or the Ocean (between Points L and M). Point M offers views of the harbor and close-up views of ships entering and leaving the Bay.

Upland Landscape Type. The primary viewpoints identified in the upland areas are Points J, K, L (Table Bluff). All these points provide elevated views of South Bay with Point L providing a spectacular view over South Spit from the edge of Table Bluff. Points J and K provide views to South Bay across agricultural lands for which the area is planned and zoned.

Urban Landscape Type. Two viewpoints within the communities of King Salmon (Point F) and Fields Landing (Point H) have been identified as providing shorefront views of the Bay. While neither is a "specially scenic community" under the meaning of the Coastal Act, both serve Tourist and Resident/Recreationists by providing boating and fishing facilities.

Visual Sensitivity

In addition to protecting the visual sensitivity of primary viewpoints as identified in the previous section, it is important to consider the overall visual sensitivity of a landscape type. Visual sensitivity can be defined as the relative degree of development that a landscape can accept without changing its inherent character. This is a function of landform and landcover. The simpler the landform and landcover (i.e., flat open grassland), the greater the visual sensitivity of the landscape to development. With this definition in mind, it is apparent that those major landscape types most sensitive to development are those that are presently open and flat such as the water surface, mudflats, and pastoral lowland areas surrounding the Bay. It is in these areas where structures such as billboards make their greatest visual impact.

Landscape types that are also sensitive to development are the open rolling grasslands at Table Bluff as well as the dune areas of North Spit that are presently undeveloped.

The landscape types least sensitive to visual change are those where the landform and landcover are more complex. These areas include the heavily wooded upland landscapes as well as the existing urban areas which visually absorb much of the new residential, commercial and industrial development.

Summary

There is considerable existing planning activity going on in Humboldt County and within the cities of Eureka and Arcata with regard to visual resources. Beginning with the Coastal Act, there exist significant policy statements to guide future permits and in the preparation of Local Coastal Programs. The staffs of local agencies, working on their own and with the Coastal staff as part of their Local Coastal Program effort, have been identifying important viewpoints and have designated some areas such as the South Spit as sensitive to development.

This profile has summarized their work and has suggested a broader framework for visual resources which considers a classification of landscape types. These landscape types provide a useful way of looking at the entire Humboldt Bay planning area and to evaluate the relative visual sensitivity of the landscape to development as well as to see the context within which the Coastal Commission has identified their viewpoints.

The primary visual resource issues within Humboldt Bay are the following:

1. Billboarding as practiced along Highway 101 is almost certainly in conflict with Coastal Act policies. No design standards for tourist-commercial facilities that would assure compatibility with Bay communities now exists.
2. No policies exist to mitigate visual impacts of industrial development on adjacent beach-woodland areas along North Spit or to protect existing open space views around the Bay from development.
3. The lowland areas contribute an important sense of visual open space and pastoral character and provide an important diverse sequential driving experience between the towns along Highway 101 and Samoa Road. The existing aesthetic character of these areas should be preserved.

C. ECONOMIC PROFILE

The economic profile of the Humboldt Bay study area is divided into three sections: (a) general economic situation; (b) discussion of selected industries; and (c) a summary of specific development projects. Discussion of the economy at the regional level was mainly dependent upon non-spatial time-series statistics by major industry available from secondary sources. Within the study area, major economic development proposals have been located as closely as possible from field observations and discussion with local industry and agency representatives.

Regional and local economic analysis was developed in the context of the Economic Development Action Plan and Strategy prepared for the Humboldt County Board of Supervisors in February 1978 (QRC Corporation, 1978). This plan was prepared with funds made available by the Economic Development Administration (EDA) to mitigate the adverse effects on the county economy caused by the expansion of Redwood National Park. Its overall goal is to raise Humboldt County's level of per capita income and to reduce the unemployment percentage to the levels of the State of California by the end of the fifth year of the action plan implementation period. Other economic information was obtained from communications with various industry representatives in the study area and from the California Department of Employment Development. An input/output model developed by Dean, Carter, Nickerson, and Adams, Structure and Projections of the Humboldt Bay Economy: Economic Growth versus Environmental Quality, California. Agricultural Experiment Station, UC, 1973, was also used.

GENERAL ECONOMIC SITUATION

Humboldt County has a variety of economic development problems which have been documented at some length in the Action Plan. This first section will summarize much of that material and on some points include more recent statistics or information from other relevant sources.

Location

One of the most significant continuing problems of development in the Humboldt region has been its particularly remote location. Because it is over 200 miles from any major growth center and/or market, the factors of location are heavily stacked against the local economy. It has particularly high transportation costs, a small local market, and labor force characteristics which reflect the dominance of several resource extraction industries.

Climatic conditions combine with location factors to intensify development problems by making communications particularly difficult. For example, the Humboldt County Airport at Arcata has approximately 5%, or 110 flights/year, of the major airline carrier cancelled because of the weather conditions. However, even though the airport has B-grade landing systems, the facilities are under-

utilized. This factor makes it difficult to justify capital expansion to higher grade facilities. Also, there has been a recent proposal by Southern Pacific Railroad to terminate rail services to the area. This action would intensify the problems of communication and transportation costs which the economy presently faces.

Employment

Employment in Humboldt County has remained static over the period 1955-1975, and regional income grew at a relatively slower rate than either the State of California or the nation over the period 1955-73 (QRC Corporation, 1978). Growth rates for the period 1955-75 and 1965-75, when adjusted for inflation, suggested actual declines in the economy. Unemployment in the area has also been a persistent social problem and has been recognized by the U.S. Department of Labor as an area of persistent chronic unemployment. Average unemployment in the area remained consistently higher than in the State of California and throughout the 1966-76 period. In 1976 unemployment in Humboldt County averaged almost 14%, compared to slightly under 10% for the state.

Structure

Another outstanding symptom of the Humboldt economy is the dominance of several resource-based sectors: timber and wood products, agriculture, fisheries, and tourism. Throughout the 1965-75 period, the lumber and wood products manufacturing sector supplied the highest private insured employment. However, these industries have been slowly declining in actual total employment and in their share of the work force. In 1977 the retail-wholesale and services sectors had the largest share of the work force. Various explanations of this structure have been advanced. One view explains this growth as the increasing influence of tourist expenditures in the retail and wholesale trade figures. Another view argues that it is a result of increases in productivity in the manufacturing sector (i.e., mainly timber and wood products) which have permitted the wage and salary earnings paid to decline less rapidly than total employment in that sector. In 1975 the lumber industry generated almost twice the wages and salary earnings of the wholesale and retail sectors. As incomes per worker in the lumber industry have increased, then a greater proportion of disposable income has generated more activity in the wholesale, retail, and services sectors. The difference between the ability of primary and secondary sectors to generate induced income is also evident from Table VIII-4, which compares Type I and Type II income multipliers from the input-output model developed by Dean in 1973. The ability of the sectors in the top half of the table to generate additional income from direct and indirect workers in each sector responding their incomes, may be reviewed by observing the differences between Type I and II multipliers. The greater the difference, then the more effective that sector is in generating induced income.

Table VIII-4

Type I* and Type II* Income Multipliers by Sector

Sector Group	Sector Description	Type I Income Multiplier	Type II Income Multiplier	Difference
Agriculture	Field Crops	1.14	1.98	.84
	Dairies	1.28	2.25	.97
	Other Ag. Products	1.26	2.34	1.08
	Meat Processing	1.27	2.11	.84
	Dairy Processing	3.68	6.38	2.70
	Other Food Processing	1.36	2.33	.97
Fishing and Mining	Seafood Processing	2.25	3.68	1.43
	Mining	1.11	1.86	.75
	Fisheries	1.14	1.87	.73
Forest Products	Forestry	1.18	2.43	1.25
	Logging	1.11	1.80	.69
	Sawmills	1.68	2.84	1.16
	Veneer-Plywood	1.38	2.31	.93
	Pulp Mills	2.21	3.96	1.75
	Other Wood Products	1.69	2.88	1.19
Other Industry	Construction	1.45	2.46	1.01
	Boat Building	1.02	1.70	.68
	Other Local Mfg.	1.12	1.88	.76
Transportation	Water Transportation	1.20	2.00	.80
	Other Transportation	1.14	1.90	.76
Trade	Comm. and Utilities	1.11	1.88	.77
	Wholesale and Retail	1.05	1.72	.67
	Finance, Insurance	1.33	2.24	.91
	Real Estate	1.08	1.79	.71
Services	Hotels and Motels	1.05	1.82	.77
	Selected Services	1.19	2.02	.83
	Entertainment	1.73	2.97	1.24
	Medical, Legal, Other	1.07	1.77	.70

*Type I Multiplier - The direct and indirect changes in income resulting from an increase of one dollar in the output of all of the industries in the processing sectors.

**Type II Multiplier - The direct and indirect changes in income plus the induced changes in income resulting from increased consumer spending. The induced effect is a measure of the expansionary effects of consumption of direct and indirect workers.

Source: The Dean model cited above.

Value Added

Another indicator of the local generation of income and employment is that of value added. This component of regional expenditures is the proportion of each sector that is paid to local households in the form of wages, salaries and return on business investments. Value added has tended to decline over the period 1958-1972 in the wood products industries but has increased in other manufacturing sectors. This observation suggests some diversification within the manufacturing sector over the period 1958-1972. However, it has been explained in the Action Plan that these data may be accounted for by the establishment of pulp mills in 1965. Even though these are classified as being part of the paper industry and consequently other manufacturing, they may still be included as a spin-off from the forest products industry. Therefore, any real diversification of the economy has only occurred to a very limited extent.

Stability

A final symptom of the existing economy's lack of growth is the lack of stability in both a seasonal and a cyclical sense. Data reported in the Action Plan clearly demonstrate the high summer peak for the resource industries (i.e. lumber, agriculture, fisheries, and tourism). Cycles or longer term changes in the economy have the characteristic of being much deeper in downturns and much less vigorous than has been the case for the state as a whole. Consequently, the local economy is extremely susceptible to complementary sectors at the state and national level. For example, when the nation as a whole suffers declines in the housing industry, there are profound impacts on the Humboldt economy. Because of the general lack of diversification of the economy, the local economy is much slower to recover than other areas in the state.

SELECTED INDUSTRIES

Those industries whose conditions and development plans most directly affect the Humboldt Bay study area are the resource-oriented industries: agriculture; fisheries; forest products; shipping and harbor development; and tourism/recreation. Because the fisheries industry is a major industry whose resources are dependent on Bay waters not only for transport but also for sustenance and renewal, it is discussed in somewhat more detail than the others.

Agriculture

Agriculture has historically been one of the major economic resources of Humboldt County. Dairying, livestock and poultry production, field and row crops, and fruit and nut crops are all part of the county's agricultural industry. Between 1967 and 1976, the

dollar value of county farm crops doubled (from 13.7 million in 1967 to 26.6 million in 1976) with the most significant growth in livestock and poultry products, field crops, and nursery production. Agriculturally related employment was estimated at 1,900 jobs in 1977, down from 2,500 in the early 1960's (QRC, 1978).

Agricultural land use in the Humboldt Bay area coastal zone was estimated by the Department of Water Resources (DWR, 1978). Agricultural use defined by DWR in the study area included grain and hay crops, field crops, pasture, truck crops, idle agricultural land, and semiagricultural land. According to DWR's figures, in a total coastal zone of 57,704 acres (area corresponding to the Humboldt Bay study area), 18,265 acres (32%) was in agricultural use. Of this, 17,215 acres (94% of agricultural lands) was in pasture, mostly mixed pasture. Only 534 acres were in truck crops (83% potatoes), 203 acres in grain and hay crops, and 94 acres in field crops (corn only). These figures emphasize the importance of dairying and livestock production (beef) as the agricultural base in the study area.

At the two-county level (Humboldt/Del Norte) agricultural production jobs are forecasted to increase by about 300 between 1976 and 1985 as intensification occurs in urban fringe areas. Because this industry is categorized with forestry and fisheries for the purpose of forecasting, an individual growth rate was not reported. In the agriculture, forestry, and fisheries sector, the growth rate projected was 4.4% through 1976-80, declining to 1.0% in the period 1980-85.

Dean (1973) used an input/output approach to forecast the Humboldt economy to 1980, as shown in the following table.

AGRICULTURAL SECTORS

<u>Sector</u>	<u>Total Employment</u>		
	<u>1963</u>	<u>1980 without tech. change</u>	<u>1980 with tech. change</u>
1. Field Crops	60	109	57
2. Dairies	571	600	313
3. Other Ag. Production	1,324	1,861	973
4. Meat Processing	10	12	6
5. Dairy Processing	146	159	100
6. Other Food Processing	138	150	67

Sectors 1, 2, and 3 show a forecasted growth of 625 agricultural production jobs for the period 1969-1980, assuming no technological change, and a reduction of 612 with technological change.

Fisheries

Fishing is big business in Humboldt Bay and shows good promise as a growth industry. The dollar volume is second only to the wood products industry, and has shown a consistent, if somewhat variable, growth trend for both commercial and recreational fisheries (QRC Corporation, 1978). Fisheries development has continued in recent years with little evidence of a decline associated with over-cropping of available stocks, although the catch of some species has leveled out. The total poundage and dollar value of fish products landed in Humboldt Bay ranged from 22.9 to 30.6 million pounds and 3.7 to 6.6 million dollars respectively in 1968-75. This represents about 3% of the pounds landed and 4% of the at-port value of the total California catch (California Department of Fish and Game, 1962). Until recently about one-half of all fish taken in Northern California were landed in Humboldt Bay, but increased shrimp landings at Crescent City from 1976 have reduced Humboldt Bay's proportion of the catch. Although the fisheries industry is an important business, it is not a large employer; annual insured employment in the fisheries/agriculture sector was about 10% of the annual insured employment in the lumber manufacturing sector in 1975.

Commercial Fishery

Humboldt Bay supports a strong offshore commercial fishery, represented largely by groundfish (such as sole and rockfish) and salmon, as contrasted with the fisheries of southern California which are dominated by migratory species such as anchovy and tuna. With the exception of the Pacific oyster, all of the major fish species harvested in the commercial fishery are taken outside Humboldt Bay itself. The Bay does support a small commercial fin fishery; however, its primary economic value comes from the employment provided by the coastal fishery, the Bay shellfishery, and facilities supporting the industry such as fish receiving and processing plants, boat moorages, marine railways, fuel and vessel supplies, and repair and communication facilities.

A large number of species are taken commercially, but only about 20 have significant value. Of 26.6 million pounds landed in 1975, there were 19.4 million pounds of groundfish, 3.7 million pounds of salmon and albacore tuna, and 3 million pounds of crabs, shrimp and oysters. Commercial landings between species do vary considerably, particularly for crabs and shrimp, and reflect an inherent instability in these fisheries. These trends are shown in Table VIII-5, which gives an eight-year summary of commercial landings from 1968-75 broken down by species and species grouping.

Coastal Fishery

Salmon and Albacore Tuna. Salmon and albacore tuna are taken commercially exclusively by trolling gear in near and offshore

Table VIII-5

EIGHT-YEAR SUMMARY OF LANDINGS IN EUREKA
(in 1,000 pounds landed)

	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>
Dover Sole	5,913	8,768	8,363	7,706	12,201	10,392	9,903	10,840
English Sole	1,807	1,149	743	580	728	714	782	613
Sanddab	195	288	246	316	388	452	233	161
Rockfish	1,318	1,697	1,983	2,379	2,960	2,954	3,326	3,236
Other Groundfish	<u>3,476</u>	<u>4,004</u>	<u>3,185</u>	<u>2,845</u>	<u>4,542</u>	<u>5,486</u>	<u>4,951</u>	<u>4,526</u>
Total Groundfish	12,709	15,906	14,520	13,826	20,819	19,998	19,195	19,376
Salmon	1,360	1,198	1,693	2,067	1,136	2,247	2,008	2,018
Albacore	1,481	3,127	4,785	1,793	512	461	1,773	1,642
Surf Perch	31	23	39	45	43	13	19	11
Smelt	230	221	405	215	351	1,085	550	455
Dungeness Crab	7,004	3,054	6,893	3,508	462	223	144	1,423
Pacific Oysters	365	351	663	693	752	568	579	455
Shrimp	131	663	1,039	293	129	63	269	1,194
Misc. & Other Species	<u>1,524</u>	<u>1,885</u>	<u>584</u>	<u>442</u>	<u>26</u>	<u>37</u>	<u>43</u>	<u>10</u>
TOTAL	24,835	26,428	30,621	22,882	24,230	24,695	23,980	26,584

Source: California Department of Fish and Game, 1969-1977.

waters immediately north and south of Humboldt Bay. No commercial salmon fishing is allowed in the Bay or within three miles of its coast. In spite of greatly increased effort, the salmon catch, as shown in Table VIII-5, has nearly leveled out. Albacore catches have fluctuated, reflecting the movement of these highly migratory subtropical fish in and out of the Humboldt area.

The fishery is believed to be extremely over-equipped (Jurick, 1979, personal communication). The salmon fishery includes approximately 300 troll-type vessels berthed in Humboldt and an additional 150 trailerable craft 15 feet or more in length, 86% of which fish salmon exclusively. Many of the vessels fish albacore, but there is still excess capacity, particularly of smaller and older vessels that lack the speed and range necessary to fish tuna.

Salmon is the most valuable fin fish on a per-pound basis taken in the Humboldt area. In the 1977 season, Eureka accounted for 41% of the state chinook landings. Of coho landed in the state, 83% were taken in Eureka or Crescent City (PFMC, 1978). Chinooks predominate in the catch in Humboldt with average landings of 1.5 million pounds from 1967-76. Coho landings averaged 0.7 million pounds during the same period and there were incidental catches of chum and pink salmon (Lesh, 1979, personal communication).

The albacore fishery is for the most part an unregulated high seas fishery, but the salmon fishery has become increasingly restrictive with limits on the type and amount of gear, seasons, and size of fish taken. Effort to manage the salmon stocks is a state and federal function, highlighted by the Fishery Conservation and Management Act (FMCA) of 1976. The coordinating unit in the Humboldt area is the Pacific Fisheries Management Council, which is made up of independent fishermen and representatives of the industry and government agencies. The Council's recommendations apply specifically to management of the federal fisheries unit from 3 to 200 nautical miles from the coast, but the State of California is expected to develop similar management policies for inshore waters. In addition to restricting fishing effort, these policies are aimed at substantially reducing the size of the fleet and limiting entry of additional fishing units (Ayers, 1979, personal communication). Critical issues likely to affect the development and present status of the fishery in Humboldt are the provisions for limited entry and treaty fishing by coastal Indian tribes and limitations on size and total catch. Decisions regarding limited entry and treaty fishing are pending court and legislative action.

An essential component in the federal and state management plans are the fishery enhancement programs. Enhancement may consist of merely clearing streams of debris and sediments to allow salmon migration or can require the construction of a multimillion dollar hatchery facility. Most hatchery programs in California are directed at augmenting natural runs and in supplying fish to support the sport

and commercial fishery. There are two salmon and steelhead trout hatcheries near the study area. One is a state hatchery maintained on the Mad River since 1970. This hatchery releases chinook and coho salmon and steelhead trout, and operates with brood stock from the Mad River as well as from other hatcheries. The Mad River hatchery has had developmental problems and it is not yet clear what the contribution of releases is to the salmon stocks off the Humboldt area (Will, 1979, personal communication).

A small coho salmon and steelhead hatchery is also operated by Humboldt County on Prairie Creek, a tributary to Redwood Creek. This hatchery uses surplus eggs from the Mad River hatchery and stocks from the Redwood and Freshwater Creek drainages. In addition, a small private coho hatchery is maintained by the Humboldt Fish Action Council near Freshwater Creek (Douglas, 1979, personal communication).

Two salmon ranching plans have been proposed for the Humboldt area. One is a wastewater treatment, reclamation, and salmon ranching project proposed by the City of Arcata at the mouth of Jolly Giant Creek (Allen and Gearheart, 1978, and George Allen, 1979, personal communication). Some reclamation development is in progress but the ocean ranching portion of the project will not, in the initial stages at least, make a significant contribution to the salmon fishery. The second proposal is a plan by Oregon/Aqua Foods (a Weyerhaeuser Corporation subsidiary) to establish a salmon ranching facility in Humboldt Bay. They require a 15 to 20 acre site located somewhere on North Spit, South Spit, Fields Landing, or King Salmon. The planned facility would be comparable to Oregon/Aqua saltwater release/return plants in Newport and Coos Bay, Oregon, with releases of about four million coho and chinook salmon and expected returns of 2% to 4%. If legislation authorizing salmon ranching on a statewide basis is passed and there is local approval, Weyerhaeuser Corporation would seek permits to construct and operate the facility on Humboldt Bay. Should legislation pass in 1979, the earliest the facility could be in operation is 1981 (Howard Johnson, 1979, personal communication).

Groundfish. Groundfish include an assemblage of species taken offshore to depths of nearly 1,000 fathoms* with large otter trawls. In general, increased groundfish catches have been the chief factor responsible for the growth of the industry in the Bay, with 70% of all groundfish landings in the state being reported from Eureka (Jurick, 1979, personal communication). Flatfish, especially the dover or slime sole, dominate the catch, but rockfish, sablefish, and lingcod are also important (Table VIII-5). There are approximately 34 boats in the Humboldt fleet. Most are day boats, but a few are capable of trips of 7+ days extending from central coastal California to Washington. New and larger multipurpose vessels capable of fishing at greater depths with larger nets and employing sophisticated fish-finding electronics are coming on line. None of these vessels are

* 30 to 60 miles offshore

being constructed in the Humboldt Bay area and most are purchased from Gulf state boat yards. The main reasons for the out-of-state purchases are reduced cost and speed of delivery (Jurick, 1979, personal communication).

Significant future increases in the Humboldt groundfish catch are predicted if species not presently taken can be harvested by U.S. fishermen. Russian fishing fleets have exploited the hake fishery for many years. The hake are now beginning to be commercially harvested by local fishermen and marketed under the name "Whiting." In addition, the catch of species dependent on rocky substrates could possibly be enhanced by nearshore habitat modification. All groundfish taken off Humboldt Bay come under the FCMA guidelines and a management unit is being prepared by the Pacific Council (tentative approval date, late 1979). Some foreign fishing is presently allowed for hake but will be reduced or banned when U.S. fishermen and processors begin taking the surplus stocks. The critical issues regarding groundfishing regulation in the Humboldt area appear to be the absence of accurate catch predictions to assess the long-term potential of the groundfishery and the impact of joint ventures on local processors. These are U.S. foreign agreements where the U.S. fishermen contract to sell their catch directly to a foreign processor (Myers and Thomas, 1979, personal communication).

Crabs and Shrimp. Crabs are taken outside Humboldt Bay and processed by Humboldt processors. This again is not a Bay fishery but does support Eureka-based fishermen and processors. All crabs are taken with pots or traps set from vessels ranging from 30 to 50 feet in length. Shrimp are not often taken off Humboldt Bay, but in good years are frequently landed in Bay markets. They are usually taken by Gulf Coast-type double-net trawlers operating out of Crescent City.

The Bay Fisheries

Oysters. Culture of the Pacific oyster, Crassostrea gigas, constitutes the largest commercial fishery in Humboldt Bay and is one of the five most important fisheries in terms of dollar value in the Humboldt area. The locations of major commercial oyster beds in Arcata Bay are shown in Plate 25. The two companies presently culturing oysters in the Bay are the Coast Oyster Company and the Pigeon Point Shellfish Hatchery (owned by WDH Enterprises).

Coast Oyster Company has large holdings in Arcata Bay under private ownership and leased from the City of Eureka, the Harbor District, and private owners. The company uses ground culture exclusively and harvests all stock with a mechanical dredge. Most of these oysters are grown on productive beds with no intermediate transfer from growing to fattening grounds. These beds are scattered over 800 to 900 acres of northern Arcata Bay between the Mad River Channel and East Bay. The company also has many beds with marginal productivity not heavily used at the present time (Douglas, 1979, personal communication).

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FISHERIES

PLATE NO 25 NORTH

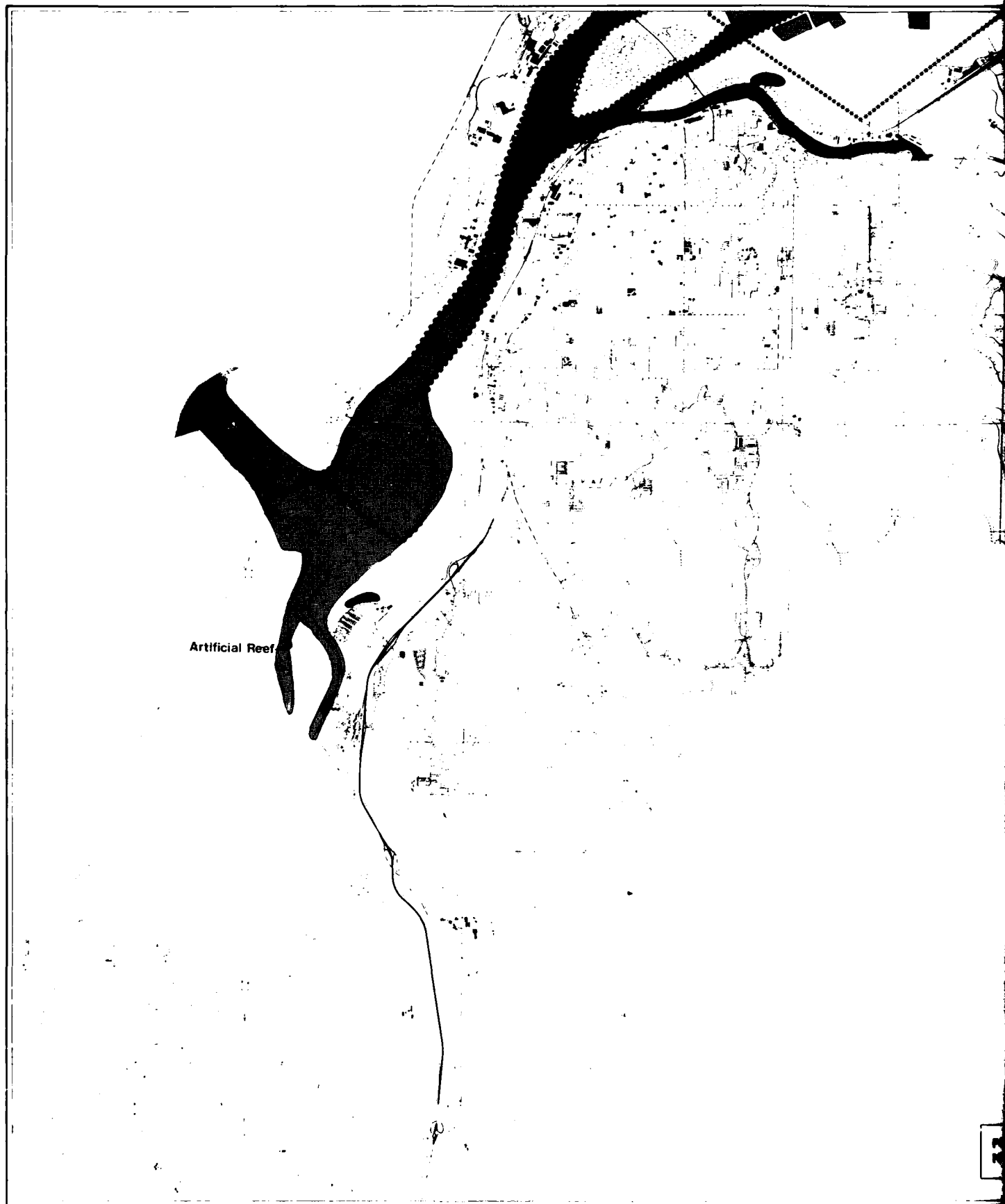
LEGEND

-  Sport Fishery
-  Herring Fishery
-  Surfperch & Rockfish Fishery
-  Pacific Oysters
-  Lease Boundary

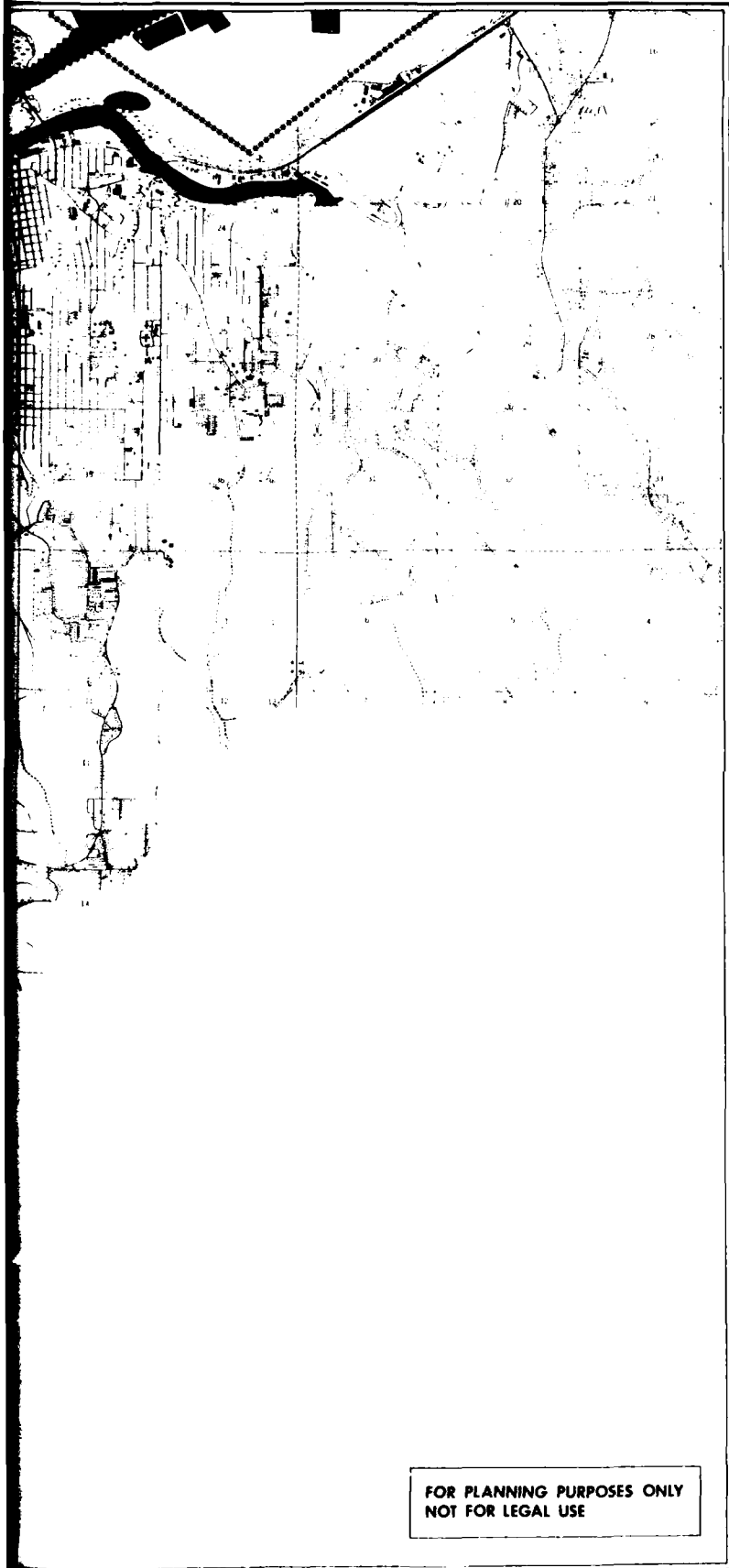


HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source Barrett, 1963
Monroe, 1973
Bob Ayers
Roger Barnhart
Frank Douglas
Fred Jurkic (PC)
Ted Kulper
Joe Lesh









Artificial Reef

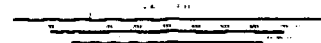


FISHERIES

PLATE NO 25 SOUTH

LEGEND

-  Sport Fishery
-  Herring Fishery
-  Surfperch & Rockfish Fishery
-  Anchovy Fishery
-  Pacific Oyster
-  Lease Boundary



HUMBOLDT BAY WETLANDS REVIEW & BAYLANDS ANALYSIS

Source: Barrett, 1983
Monroe, 1973
Bob Ayers
Roger Barnhart
Frank Douglas
Fred Jurick (PC)
Ted Kulper
Joe Lesh

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The Pigeon Point Shellfish Hatchery has leased holdings in the Mad River Slough between the Lamphere Road Bridge and the Samoa Boulevard Bridge. Oysters are cultured in trays and lantern nets suspended from floats. Pigeon Point anticipates culture on 60 acres of land near the west side of the Mad River Slough channel, 500 yards south of the Samoa Boulevard Bridge (Kuiper, 1979, personal communication).

Both companies express an optimistic view of the future of oyster culture in Humboldt Bay. Coast Oyster Company is a large firm of 40 employees with a standing crop of 50 to 100 million oysters. The yearly production is up to 100,000 gallons (875,000 pounds) of shucked meats at a present market value of \$1,700,000. They believe that present production is optimum for the bay and that increased stocking would not make a significant contribution to total production. They are not planning to use rack or tray culture except for seed stock. Therefore, their operations will still continue to be dependent on maintenance of suitable substrate. Pigeon Point, on the other hand, is a small operation of 10-14 employees with a standing crop of 2 to 6 million oysters. They believe the Bay has the capacity for greatly increased production without constraining overall productivity. Their use of rack and tray culture is not necessarily substrate dependent and a large number of suitable shellfish growing sites are probably available in the Bay. Both operators are subject to closure following heavy rains due to fecal contamination of their oysters. This is primarily seen to be a problem with regard to human pollution; agricultural runoff is thought to increase bay productivity by nutrient enrichment. Neither operator is culturing the small native or Olympia oyster, *Ostrea lurida*, although they noted that it is still common in the Bay. Olympia oysters were cultured in diked beds in the 1930's (Barret, 1963).

Herring. There is a small herring fishery in Humboldt Bay based on the capture of the fish with gill nets to supply a roe market in Japan. It is a limited fishery with four small boats restricted to quotas of 50 tons or less. In the summer of 1978 this fishery lasted 1-1/2 weeks. The quota may be increased, but the fishery has been criticized by recreational fishermen for reducing stocks of forage and bait fish in the bay (Jurick and Warner, 1979, personal communication). Anticipated capture areas are shown in Plate 20.

Anchovy. A limited tuna baitboat fishery occurs in Humboldt Bay from mid-August to September. The tuna fishermen set lampara nets (purse seines) for bait only. The fishery will probably be confined to the areas shown in Plate 25, with the harvest rate set at 15% of the standing crop (Barnhart and Glatzel, 1979, personal communication).

Surfperch. Surfperch are taken in small numbers by hook and line (redtail surfperch) or traps (pile and striped surfperch) in locations shown in Plate 25.

Other Bay Fisheries. Small numbers of Washington or butter clams are taken from South Bay to supply local markets and restaurants. Harvest volumes are insignificant compared with the recreational clam take (Glatzel, 1979, personal communication; Monroe, 1973). This fishery is limited to a few part-time diggers.

A non-food fishery exists for the bat ray, considered by oyster growers to be a serious pest on commercial beds. Boomer (1979, personal communication) now believes the rays do not eat oysters but feed on clams and worms.

Economic Trends

Growth of the industry in Humboldt Bay can occur by utilizing stocks not presently harvested or cultured, increasing the supply of existing stocks, or expanding into new markets. The demand for fish products in traditional markets already exceeds the supply and it is unlikely that it can be saturated by the domestic fishery. Management reductions in the numbers of fish which can be taken (i.e., for salmon) may or may not be compensated by increased value. The price may become too high and suppress demand (Thomas and Ayers, 1979, personal communication).

As noted above, the groundfishery is expected to have a positive effect on the industry. The FMCA of 1976 encourages the industry to harvest species of fish which have been caught in small amounts, or which have been caught in significant amounts but discarded. Examples of underutilized and unutilized fish and shellfish thought to have the most commercial potential in this area are hake, squid, smelt, shark, bay and surf clams, skates, saury, tanner crab, tomcod, jack mackerel, grenadiers, and octopus (QRC, 1978). Entrance by Humboldt fishermen and processors into these fisheries may stabilize catch trends and result in increased production by processors. This expansion will require new vessels and development of a domestic market. Both Lazio's Sea Foods and Eureka Fisheries, Inc. anticipate expanding existing processing lines for hake once a market can be established. This would probably not entail a facilities expansion or utilization of any additional land areas (Vince Thomas and Jerry Thomas, 1979, personal communication). Commercial harvest of Bay clams actually appears to have limited potential (Douglas, 1979). Population densities are low on many beds and a mechanical harvester would probably be required for a commercially profitable fishery.

Shellfish and finfish culture also show potential for expansion in the Bay. Both require substantial wetland acreage and good water quality, either for the actual culture operation or as a source of productive growing water. Ocean ranching of salmon is pro-

ceeding nearly as outlined in the Humboldt County Economic Action Plan (QRC Corporation, 1978). The principal expansion in the Humboldt area is the planned Oregon/Aqua Foods salmon ranch. This facility would require an initial investment of 3-5 million dollars and total employment of about 10-15 persons (Howard Johnson, 1979, personal communication). In addition, a small facility is being developed at the Arcata wastewater pond (Allen, 1979, personal communication). The Humboldt County Economic Action Plan identifies mussel, crab, and seaweed as possible mariculture projects that would directly affect the Bay. Operating areas and constraints are similar for the proposed mussel and seaweed projects and existing oyster culture. The crab farming project is an experimental concept requiring significant research and development before commercial application. No new species utilization or major changes in oyster culture acreage or employment are expected in the next few years beyond the 60 acre expansion by Pigeon Point. The Action Plan also proposes hatchery and stream improvement and the development of salmonid rearing ponds. Emphasis is on improvement of the Mad River hatchery and expansion of the Fish Action Council's pond rearing program. No additional pond or rearing facilities are anticipated in this proposal; however, if the projects are carried out as proposed, they should result in significant increases in potential salmonid rearing capacity in the Humboldt area.

Fishing vessel and processing plant capacity are believed to be adequate for the capacity of existing fisheries (Vince Thomas and Jerry Thomas, 1979, personal communication). Berthing facilities will become a limiting factor in the ability of Eureka to support an expanded groundfishery, especially for the larger vessels. Support industries for fisheries are complemented by the wood products industry and give Eureka a competitive advantage over other north coast communities. No change in the present trend of out-of-area purchase of vessels is expected, however, due to the high cost of vessel construction in Eureka (Jurick, 1979, personal communication). The Action Plan identifies possible projects that could take place to support the industry. These include establishment of a seafood technology demonstration program, establishment of a fish by-products factory, and an exploratory fishing project. These are projects centering on the offshore fishery and would, with the exception of the fish by-products factory, not require major facilities expansion or new construction.

Recreational Fishing

Finfishing

Sport fishing accounts for the majority of the finfish and shellfish (other than oysters) landed within Humboldt Bay and within three miles of the mouth of the Bay. Salmon are taken almost exclusively outside of the Bay by party boats and skiffs. The total sport salmon catch has remained at or slightly above the 1975 figures of

1,183 salmon from party boats and 16,804 from private skiffs (California Department of Fish and Game, 1976). The Humboldt salmon catches are 1.6% and 33% of the state totals for party boats and private skiffs, respectively. While there appears to be room for expansion of the party boat fleet, poor catch rates (0.4 fish per day in Humboldt versus the state average of 0.9 fish per day), reduced catch and size limits, and an absence of suitable alternative species make this fishery unattractive for new fishermen or the commercial fishermen who might wish to transfer his operation to a charter fishery (PFMC, 1978). Both the party boats and private skiffs can generate large amounts of local revenue; for example, the economic value of the party boat fishery is approximately \$63 per day in 1970 dollars (PFMC, 1978). An estimate of 21,000 angler days were expended in the combined party boat and skiff fishery off Humboldt in 1978 (Lesh, 1979, personal communication).

While sport finfishery information of species taken within the Bay is somewhat sketchy, a general impression of species taken and areas fished can be obtained from Squire and Smith (1977) and Smith, et al. (1976). These observations are summarized in Plate 25 (see also Section VIII, A.3., Cultural Resources, Recreation). Popular sport fishing spots in Humboldt Bay are the South Jetty and the Buhne Point jetty at the PG&E Company power plant near the thermal effluent discharge points. Piers and the small artificial reef in South Bay are also common fishing sites. No recent catch data are available from this fishery, but California Department of Fish and Game estimated in 1957-60 that an average of 27,144 angler days were expended annually in the Bay during the survey period (Monroe, 1973).

Shellfishing

Sport shellfishing is an important recreational use of Humboldt Bay waters. Native oysters, clams, crabs, and sportfishing baits (e.g., invertebrates such as ghost shrimp and polychaetes) are taken in the Bay. Clam digging represents the greatest shellfishing effort with the gaper or horse clams, Washington or butter clams, and native littleneck dominating the catch (Warner, 1979, personal communication).

According to Monroe (1973), most of the clamming effort takes place in South Humboldt Bay, probably because the clam beds are more accessible and because desirable clam species are more abundant there than in Arcata Bay. The most popular areas in South Bay for clam digging are the northern end of Clam Island and Buhne Point. In Arcata Bay, clamming effort is greatest in Indian Island, Bird Island, Sand Island, and along the Mad River Channel. Native oysters are also taken in Arcata Bay; they are most abundant north of Woodley Island and in the Arcata Channel. Generalized locations of crab and clam beds are shown in Plate 13.

Economic Trends

The future of recreational fishing in Humboldt Bay is under the same constraints as the commercial fisheries. No real expansion of the salmon sport fishery is possible without major increases in natural runs or artificial releases. Indeed, the fishery is now declining and will probably become increasingly restrictive (PFMC, 1978). Very little effort is being expended to increase the yields and manage non-salmonid sport fish and this trend will most likely continue in the foreseeable future. Expansion of the clam sport fishery in South Bay may be restricted by the wildlife refuge.

In certain instances sport fishermen may compete with commercial fishermen for the resource as well as berthing spaces and support facilities in the Bay. Sport fishing organizations will continue to be strong proponents of marina developments, launching ramps, artificial reefs, and fishing piers, but may take a stand against shoreline developments restricting access or reducing potential fisheries production.

Employment

Because of gross categorization, it was not possible to derive a two-county State of California forecast for the fisheries sector. (Agriculture, forestry and fisheries are lumped together, and fisheries does not include fish processing.) However, the Dean Model (1973) projected employment within Humboldt County in the fisheries sector (which includes fish processing) to grow from a 1969 level of 997 to 1,382 (38.6% increase) without technological change and to 1,054 with technological change (5.7% increase).

The impact of the 200-mile limit makes forecasting of the fisheries sector difficult. According to local sources and the fisheries consultant (D. Cheney, Ph.D.), it will affect the salmon fishery (which accounts for 10-15% of the present total) with a downward trend expected. The groundfish harvest, which accounts for 50-60% of the total catch, is expected to remain at a stable level.

Forest Products

The forest products industry has always been one of the most important industries in Humboldt County. In 1975, 27% of insured employment was engaged in this sector which represents a decline of 12% since 1965 (2,700 job decline). The Action Plan claims that one of the most important stimuli that is needed for the industry is the continued development of a favorable business climate. The most important problem facing the present industry is the need to convert to second growth timber while maintaining older equipment for processing of old growth timber (QRC, 1978).

Sawmills and plywood factories have the general problem of outdated processing equipment and also have other problems more unique to the type of activity (for example, management problems in sawmills and need to develop new market lines in plywood). Secondary manufacturing of forest products has limited potential because its transportation costs favor market orientation. With over 220,000 acres of hardwood on private lands, development of hardwoods manufacturing is a real possibility.

Exports of logs and lumber from Humboldt Bay have averaged about 102.6 million board feet per year (Scribner Scale) for the 1972-1976 period. Both log and lumber exports vary considerably from year to year. Lumber exports have shown a steady downward trend since 1967; whereas, log exports have declined since a high in 1968 and then increased significantly in 1976 (by almost 50% of 1975 volume). The estimated total export volume for 1977 was only about 60% of the average for the 1972-1976 period (QRC, 1978).

At the two-county level (Humboldt-Del Norte) the forest products industry is projected to slowly decline in both income and employment. Even though the industry has traditionally dominated the manufacturing sector in the region, a declining supply of raw materials and advancement in technology have combined to bring about a relative decline of the industry. An example of this decline is the closing of Halverson Lumber Products by the end of 1979 as a result of expansion of the Redwoods National Park (Halverson, 1979, personal communication). However, there is some feeling in the study area that lumber exports to Japan may increase, as many local mills are being approached by Japanese representatives at present (Guynup, 1979, personal communication). Although lumber export has been showing a steady decrease since 1967, such export may now be starting to increase, and there is hope for cultivation of trade with China (Guynup, 1979, personal communication). In pulp production, the raw material base could be extended, with chips brought in from a wider area (Hall, 1979, personal communication).

It is anticipated the diversification into the utilization of hardwoods and a movement toward labor intensive logging operations (e.g., select cutting) will help to retard the decline in employment. Lumber and wood products is forecasted to decline in total employment in 1976, from 8,700 down to 8,500 by 1980, and 7,700 by 1985. This represents an annual compound decline of 6% in the 1976-1980 period and a 2.0% decline in the 1980-1985 period.

In Humboldt County the same trends apply to the industry. Using the data time series 1965-1976 for the lumber and wood products industry, and regressing over time (linear regression), the forecasted values for 1980 employment were 6,800 in 1980 and 6,100 in 1985.

The input/output model (Dean, 1973) forecasted forest products employment to decline from 8,339 jobs in 1969 to a 1980 value of 6,489 without technological change, or 4,540 with technological change. Net annual declines would average 2.2% (no technological change) or 4.5% (technological change). The expansion of the Redwoods National Park was not included in this forecast. However, variations in the forestry sector and in local government expenditures (LGE) were hypothesized. Variations included 1980 Base Model (905 MBF forestry output, 1969 level of LGE); Projection A (reduction to 700 MBF, 50% less than 1969 LGE); Projection C (1969 MBF level of forestry output, 100% more than 1969 LGE).

Shipping and Harbor Development

Shipping facilities at Humboldt Bay serve primarily the forest products and petroleum industries. Commodity flows in and out of the Bay are principally the export of forest products and the import of petroleum products for local consumption and chemicals for wood pulp processing. Forest products exports are logs, woodchips, lumber, plywood, and pulp. Logs, woodpulp and woodchips are the major shipments, with woodchips increasing in tonnage (QRC, 1978).

The number of vessels calling on Humboldt Bay average about 350 per year. Dry cargo vessels range in length between 500 and 600 feet and in draft between 26 and 30 feet (QRC, 1978). About 80% of the Bay's vessel traffic uses the North Bay channel, which is deeper.

There are nine dry cargo docks in Humboldt Bay. Two are located in Fields Landing, of which one (Olson Terminals) is used for log export and the other (Pacific Dock) is not used for shipping. Two are located in Eureka's downtown waterfront, of which one (Humboldt Dock A) is used for export of lumber, pulp, and plywood and the other (Humboldt Dock B) is used for fish receiving and processing (no shipping). One dry-cargo dock, belonging to Eureka Forest Products and used for log export, is in the Eureka-Bucksport strip west of Broadway. The other four docks are on the North Spit at Fairhaven and Samoa; they are the Louisiana-Pacific Redwood Dock (pulp and lumber export), the Louisiana-Pacific Chip Berth (woodchip export), the Crown-Simpson Pulp Dock (pulp export, some oil and chemical import), and the North Coast Export Company Dock (woodchip export). The North Spit docks can accommodate vessels over 700 feet long. All the dry-cargo docks except the Crown-Simpson dock are public docks.

The three oil terminals, Standard Oil, Union Oil, and Oregon Coast Towing Company (formerly Oil Terminals, Inc.), are located in the Eureka-Bucksport strip and are privately owned (the Shell Terminal east of Indian Island is now inactive). Oregon Coast Towing's parent industry is marine transport and container shipping.

Four characteristics of the Bay's terminal facilities determine their adequacy for shipping (QRC, 1978).

1. Accessibility and vessel accommodation - the channels are generally too shallow and narrow and this restricts water-borne commerce. Dock and berthing facilities are more than adequate for current needs (operating at 20-30% of capacity).
2. Loading and off-loading equipment - adequate for the type and volume of cargo currently shipped.
3. Storage and processing facilities - adequate given the current product mix and shipping volumes, but an absence of first-class warehouse spaces.
4. Accessibility to land transportation - difficult to the east. Highway 101 provides good north-south access. Railroad transport is limited to the southern direction. Rail service may be suspended in the near future, further restricting land accessibility.

The Corps of Engineers has recently completed a number of navigation improvements in the Bay (COE, 1976(1)), including:

- . deepening the North Bay channel from 30 to 35 feet and widening it at three bends.
- . deepening a portion of the Eureka channel from 30 to 35 feet.
- . deepening the Samoa channel from 30 to 35 feet and widening it along the entire length.
- . constructing a turning basin 35 feet deep at the head of the Samoa channel.

Approximately 2.4 million cubic yards of material was dredged and placed on three disposal sites (COE, 1976(2)) on the North Spit. Two of the disposal sites are upland and one is an ocean beach site. The two upland sites (13A and 13B) are at Fairhaven: 13A, between the Navy Base Road and the railroad tracks, and 13B, west of the Navy Base Road adjacent to the drag strip (Eureka airport). The beach site (17) is located along the ocean beach north and west of Samoa and west of an abandoned bark dump site. These sites were chosen after considerable public input; in fact, a previously chosen site, 13C just north of the Coast Guard Station, was eliminated because of public interest in maintaining the native habitat of Erysimum menziesii.

The Corps is also designing and evaluating a navigation improvement project for the Fields Landing channel, including widening and deepening the channel. A real concern with this project is loss of eelgrass habitat.

Expansion of shipping activity within Humboldt Bay is difficult to project because of many factors. The development of Humboldt Bay Harbor is closely related to the forest products industry. According to the Action Plan (QRC, 1978) there is no other existing base from which to expect significant sources of demand for shipping. In 1977, only 9% of the county's timber production was transported from Humboldt Bay terminals.

Projections for vessel traffic through the year 2000 indicate a stable level of vessel trips. The amount of commodity flows through Bay terminals is not expected to change significantly due to the effects of Corps dredging, and the forest products industry is not expected to expand sufficiently to make new shipping facilities necessary (QRC, 1978). Development of OCS support facilities, including shipping and equipment construction facilities, in Humboldt Bay may be feasible, but no specific projections have been made (Keene, 1979, personal communication). However, should new facilities become necessary, several potential harbor-related development sites have been identified (QRC, 1978); these are at King Salmon, at Fields Landing, on the North Spit between Louisiana Pacific Ship Berth and the Crown Simpson Dock, and in the Eureka-Bucksport area.

Tourism/Recreation

The importance of tourism and recreation to the Humboldt economy is difficult to estimate from secondary sources. Because of the methods of data reporting, tourist expenditures cannot readily be separated from commercial and local expenditures. There have been some suggestions that tourism/recreation is the second major industry in the County, but there is little data to support this (Ridenhour, 1979, personal communication). Some field interviews and surveys indicate that most people drive on through (Peterson, 1979, personal communication). No adequate analysis of tourism/recreation has been done, because of lack of data; tourism/recreation data needs to be collected (Ridenhour, 1979, personal communication). There are some indicators which point to tourism and recreation as a significant seasonal part of the economy (as are timber, fishing, and agriculture). Information reported in the Action Plan (QRC, 1978) shows that the tourist component of traffic entering the County during the peak traffic months is in the range of 55-65% of total traffic. Seasonal traffic variation is extremely high with January traffic being approximately 60% of average daily traffic and August 150% of average daily traffic.

Other data reported to demonstrate the seasonal nature of tourist activity is the City of Eureka's transient occupancy taxes for the past twelve quarters is shown in the following table.

TRANSIENT OCCUPANCY TAX REVENUES
City of Eureka

<u>Quarter</u>	<u>F/Y 1975</u>	<u>F/Y 1976</u>	<u>F/Y 1977</u>
July-September	67,514	91,521	105,113
October-December	36,187	40,322	61,638
January-March	34,384	41,355	49,822
April-June	<u>35,655</u>	<u>50,611</u>	<u>62,304</u>
TOTAL	173,740	223,809	278,877

The tax revenues in July-September are approximately double those in January to March.

Insured employment in sectors related to tourism/recreation (wholesale/retail trade and services) exceeded that in the manufacturing sector by almost 50% in 1975. Over the period 1965-1975, employment in these sectors has increased while manufacturing employment has decreased (QRC, 1978; California Department of Employment Development, Report #127 series).

Sites available and used for recreation are discussed in Section VIII.A.3, Recreation, and shown on Plate 21. These sites include marinas and boat ramps. Boating is a major recreational activity in the study area; much recreational fishing involves boating (see Fisheries above). The Humboldt Bay Master Plan (Koebig and Koebig, 1975) concluded that there was a clear need for additional boat berths in the Bay. The Woodley Island Marina will help alleviate the berth shortage. A need for additional boat launch facilities was also found; the best locations were felt to be King Salmon/Fields Landing, the Eureka Boat Basin, and the North and South Spits. One of the most important requirements of new launching facilities is the provision of a full range of boating and recreational services. The extent of the economic impact of recreational boating on a local economy is difficult to estimate with the data available. However, it has been suggested that present impact is not very significant because of the general lack of shoreside facilities to induce residents and tourists to spend their vacation within the County or, in the case of tourists, stay longer in the County (QRC, 1978).

Forecasts for the two-county area for trade and services sectors show tourism to be a major catalyst for growth in the local economy. Retail trade employment is forecasted to increase from 8,500 in 1976 to 9,700 in 1980 and 11,200 in 1985. Employment in hotels and lodging places is forecasted to increase from 1,400 in 1976 to 1,600 in 1980 and 1,900 by 1985 (California Department of Employment Development, 1979).

The following table shows input/output model forecasts (Dean, 1973) for the tourism-related sectors; significant growth is forecasted.

EMPLOYMENT FORECASTS
TOURISM-RELATED SECTORS

<u>Sector</u>	<u>1969</u>	<u>Employment</u>	
		<u>with</u> <u>tech.</u> <u>change</u>	<u>without</u> <u>tech.</u> <u>change</u>
Retail/Wholesale Trade	7,400	9,103	6,827
Hotels and Motels	699	1,445	1,107
Entertainment	561	761	609

As a further forecast, a linear regression and forecast using the employment time-series 1965-1975 was run for the retail/wholesale trade sector. Employment in this sector was forecasted to grow from 7,425 in 1975 to 7,900 in 1980 and 8,800 by 1985.

Specific Development Proposals and New Economic Directions

At present a principal stimulus to industrial and commercial development in the study area is the Title 9 Economic Development Administration Funding (EDA) of \$5.5 million for one year. Title 9 funding designates economic development funds for regions which have been impacted as a result of Federal government actions; in this case, the expansion of Redwoods National Park. The Title 9 funds are administered by the Redwood Region Economic Development Commission (RREDC). Three projects had been funded from this grant as of January 1979:

- 1) Humboldt County Airport Improvements, subcontract grant to Humboldt County (approximately \$2 million)
- 2) Boat Repair and Construction Facility, subcontract grant to the Humboldt Bay Harbor Recreation and Conservation District (approximately \$2 million)
- 3) Hardwood Industry Technical Assistance Grant (approximately \$60,000)

An additional \$935,000 was set aside for business and development loans for F/Y 1979. As of February 1979 there had been \$3,117,720 in requests to the RREDC, mostly for loans in the \$20-\$30,000 range. Of 36 loan applications, four were for about \$300,000, one was for \$650,000, and one at about \$1 million. The business loan applications by category were as follows:

<u>Category</u>	<u>Number of Loans</u>
Agriculture and Forestry	3
Manufacturing:	
Food Products	3
Lumber and Wood Products	5
Electric and Machinery	2
Other Misc. Manufacturing	1
Trucking and Warehousing	1
Wholesale Trade	2
Food and Dairy Product Stores	2
Eating and Drinking Places	4
Retail Trade	4
Finance, Accounting	1
Hotels and Other Personal Services	2
Business and Repair Services	6
Entertainment, Recreational Services	1
Professional Services	<u>1</u>
Total Loans	38
Total Applications (some applications are in two categories)	36

Funding for the Woodley Island Marina has been granted, and the marina is now under construction. The Woodley Island Marina grant was originally applied for under Title 1, separate from the economic development funds (\$5.5 million for the marina) (Ridenhour, 1979, personal communication).

Other specific development proposals and ideas for economic development by various sources in the study area are listed below:

1. An industrial park, located on North Spit somewhere east of Navy Base Road, north of Fairhaven, and south of Mad River Slough. This is not a specific proposal yet, only a general consideration of the RREDC (Ridenhour, 1979, personal communication).
2. Light manufacturing or assembly plants, such as electronics, car assembly, or the diving and survival suit manufacturer in Fortuna. The advantage of such industry is in using people, not natural resources (Peterson, 1979, personal communication).
3. An economic development corporation established by Arcata to develop an industrial park site (Ridenhour, 1979, personal communication).
4. Arts/crafts and cottage industries, proposed by the Redwood Community Development Council (Peterson, 1979, personal communication).

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HUMBOLDT BAY WETLANDS REVIEW AND BAYLANDS ANALYSIS. VOLUME II. --ETC(U)

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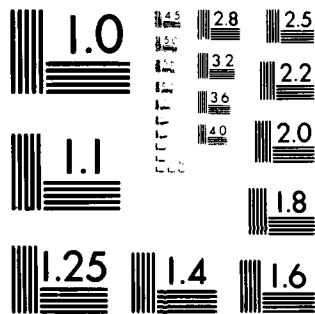
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5. A salmon ranching facility in the Bay, proposed by Oregon/Aqua Foods. It would require a 15-20 acre site on North or South Spit, Fields Landing, or King Salmon.
6. A wastewater treatment, marsh reclamation, and salmon ranching project proposed by Arcata at the mouth of Jolly Giant Creek. The marsh reclamation portion of this proposal has been separately approved for funding by the Coastal Conservancy (see Section VIII.A.3, Recreation).
7. Oyster culture proposed by Pigeon Point Shellfish Hatchery on 60 acres near the west side of the Mad River Slough channel, 500 yards south of the Samoa Boulevard Bridge.
8. Improvement of the Mad River hatchery and expansion of the Fish Action Council's pond rearing program, proposed in the Action Plan (QRC, 1978). The Action Plan also proposes a fish by-products factory.
9. A plant designed to receive and process hardwoods, described in the Action Plan (QRC, 1978).
10. A woodchip power plant, proposed by North Coast Export on the North Spit south of Samoa. The site is the same as that proposed for the regional sewage treatment plant (Stratford, 1978, personal communication; Weeks, 1979, personal communication).
11. A power plant on the North Spit by Louisiana-Pacific (Weeks, 1979, personal communication).
12. A tanker facility for fuel delivery at PG&E location (Weeks, 1979, personal communication).
13. A 5-20 acre site for a container terminal somewhere in the Bay.
14. Support facilities for OCS development, completely unspecified at this time. However, such facilities might include tanker loading docks, storage facilities, and/or equipment construction facilities (for example, a graving dock for tower construction) (Carleson, 1979, personal communication; Guynup, 1979, personal communication; Keene, 1979, personal communication).

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